SCIENCE ABSTRACTS.

Section A.—PHYSICS.

SEPTEMBER 1913.

GENERAL PHYSICS.

1374. ***Integraph for the Differential Equation of the Motion of a Projectile through an Ordinary Medium.*** **E. Pascal.** (Accad. Lincei, Atti, 22. pp. 749–756, May 31, 1913.)—Hitherto only special cases of the differential equation have been capable of integration, such as those dealt with by D'Alembert, Siacci, Appell, and Ouivet. The author now describes a modification of the Abakanowicz integraph [Abstracts Nos. 2478 (1904) and 88 (1910)] by means of which the general differential equation may be solved graphically.
W. H. Si.

1375. 1000-*Ton Testing Machine at the Bureau of Standards.* **M. Kurrein.** (Zeitschr. Vereines Deutsch. Ing. 57. pp. 1125–1132, July 19, 1913.)—Illustrated description of the Emery testing machine. This is of the horizontal hydraulic type, and its capacity is 1040 tons in compression and 520 tons in tension, both obtained direct from the cylinder in the movable head. The bedplate does not take any part in the transmission of the load which is all carried by the two screwed bars. The pump and accumulator are arranged to give, by varying the connections, pressures of 20, 90, 152, and 220 atmos. The load is measured by an arrangement of hydraulic diaphragm gauges (*Messdosen*) which is largely novel. There are three of these gauges in the fixed head: two for compression, arranged on either side of the centre plane containing the tie bars, so that any eccentricity of loading is indicated, and one for tension. The gauge pressures are measured by a multiple lever weighing apparatus, actuated by small diaphragm gauges, which communicate by pipes with the measuring boxes in the head of the machine. The calibration of the gauges is described. It is not necessary to send them to the makers for this purpose unless two or more are injured simultaneously. The makers have a special press for the calibration of the gauges, which is also described. The max. length of test-piece admitted by the machine is about 10 m. [*Erratum*, Ibid. p. 1241, Aug. 2, 1913.]
F. R.

1376. *Optical Method for Calibrating Barometer and Thermometer Tubes.* **S. W. Wicksell-Gyllenberg.** (Zeitschr. Instrumentenk. 33. pp. 188–192, June, 1913.)—Methods are described and formulæ derived by which the internal diam. of a glass tube may be determined by use of a microscope, viewing the tube perpendicular to its length. The cases dealt with are (i) where the tube is accurately cylindrical, and (ii) where the tube deviates from the cylindrical form, as is almost always the case in practice. Examples of the methods show that the formulæ give results of about the same order of accuracy as are obtained with direct measurements of the fractured tube.

A. W.

1377. *Flexure Correction for Torsion Balance.* **V. Crémieu.** (Comptes Rendus, 156. pp. 617–620, Feb. 24, 1913.)—A previous paper [Abstract No. 1157 (1909)] is continued, giving more complete analysis of the effect of flexure of the suspension fibre of torsion balances. Flexure may occur near the point of suspension or near the attachment of the weight system, and the three cases where these occur singly or together are analysed. It is shown how these conditions may affect the sensibility of the system, and attention is drawn to the possible application of the idea to the construction of seismographs, dynamometers, and microbalances. C. P. B.

1378. *Load-extension Diagrams taken with the Optical Load Extension Indicator.* **W. E. Dalby.** (Roy. Soc., Proc. Ser. A. 88. pp. 281–288, May 8, 1913. Engineering, 96. pp. 99–101, July 18, 1913.)—Using the optical indicator described in Abstract No 1142 (1912), the author has determined the physical properties of gun metal, brass, and phosphor bronze. The diagrams are made up of two parts—the elastic or quasi-elastic and the plastic part. In the case of steel the change is abrupt, but in the case of copper and its alloys it is impossible to say where the elastic part ends and the plastic part begins. The curve is smooth and continuous from the commencement of loading to the point of fracture. In the case of brass the diagrams amplify the marked influence of annealing on the physical properties of the material. In the unannealed bar there is a quasi-elastic period up to about 7 tons, but after annealing this period only lasts up to about 2 tons. Experiments on the rapidity of breaking show that in the case of mild steel there is very little effect on the yield and maximum stresses. The extension and contraction, however, are both increased by rapid loading to fracture. An extensometer specially designed to give a magnified elastic portion of the curve indicated a correct value for the elastic modulus of steel, and showed that copper has no true elastic modulus. It appears, therefore, that another definition is required for the modulus of this class of material, and it is proposed to define it as the ratio between unit stress and unit strain measured from a tangent at the origin of the diagram. F. C. A. H. L.

1379. *Deformation Law of the Flat Spiral Spring of a Chronometer.* **M. Moulin.** (Comptes Rendus, 156, pp. 1518–1521, May 19, 1913.)—Spiral springs of pocket chronometers are obtained by rolling three or four wires about a common axis. The distance between two consecutive spires is therefore constant by construction. Among the different spiral curves the circular involute is that which satisfies this condition, and the author assumes the spiral to possess this shape. The case of zero thickness is then considered and Grossmann's limiting value, when the number of turns is large, for an Archimedes spiral is obtained. The author claims to have verified his deformation formula not only for complete spirals of 15 to 20 turns, but also for the exterior and interior spires. The effect of a couple acting on the spires is then investigated, and the new curve found to be no longer a circular involute, but an involute of an involute of step varying with the angle turned through by the normal to the exterior extremity. The spiral remains concentric in a curve differing little from that of Phillips. In the previous spirals the formula is not rigorously applicable to interior spires whose thickness is not negligible compared with the radius of curvature, although as a rule the error is very small. Another assumption in the previous investigation has been that of a fixed centre, although in reality it is the exterior extremity which is fixed. The latter case is then considered. [*Erratum*, Ibid. p. 1642, May 26, 1918.] H. H. Ho.

1380. *Elongation of Indiarubber.* **S. Ono.** (Mathematico-Physical Soc., Tōkyō, Proc. 7. pp. 36–43, March, 1918.)—A formula founded on some assumptions is empirically altered to: $S = A\,[1 - 2/(\lambda + \beta)]\,e^{h(p-\lambda)^2}$, and then is in fair agreement with the author's experimental results. Here S is the stress per unit of original area, λ is (strained length)/(original length), β is (strained breadth)/(original breadth), and A, h, and p are constants. Results are given for several specimens of indiarubber. $A/\sqrt{h}$ is approximately 400 gm. per mm.^{2} for all the specimens, and p is roughly 8·8 for all specimens, with one exception. The tests were in each case made at constant temperature to a fraction of a degree, namely at from 10° to 18° C. F. R.

1381. *Lateral Independence of the Balance Wheel of a Marine Chronometer. Decrease in Isochronism Disturbance due to the Inertia of the Regulating Spring.* **J. Andrade.** (Comptes Rendus, 166. pp. 1454–1456, May 13, 1918.)—In a previous note [see Abstract No. 1242 (1918)] the author has evaluated the pressure exercised by a double spiral, giving necessary corrections. Also the complete elimination of all pressure upon the axis of the balance wheel is shown to be obtained by employing two double spirals conveniently chosen. The author now discusses the order of approximation of the lateral independence, which is found to be lower than $(1/14) \times 10^{-7}$, and remarks that the lateral freedom is practically complete. The condition of adjustment for the double spirals is then investigated, and it is shown that small perturbations of the isochronism, produced by the inertia of the regulating spring, can be considerably diminished, since these perturbations depend on the moments of inertia of the springs with respect to the axis of the balance wheel. These results are of interest both from the standpoint of regulation and also of cost, since a considerable reduction in total mass is obtained and the springs are generally made of palladium. H. H. Ho.

1382. *Approximate Determination of Period of Stable System.* **A. Mallock.** (Roy. Soc., Proc. Ser. A. 88. pp. 333–335, June 2, 1918.)—In practice, the elastic displacements of a stable system can be represented by the swings of a pendulum with the period of the mode of vibration considered and an effective mass equal to the structural mass subject to vibration, concentrated at what may be called the centre of oscillation. Let l be the length of the equivalent simple pendulum, σ the stiffness of the structure, and W its weight. Choose x_1 so that $W = \sigma x_1 =$ force causing displacement x_1 at centre of oscillation. Then period τ is given by equations $\tau = 2\pi\sqrt{l/g}$; $\tau = 2\pi\sqrt{W/g\sigma}$, $\therefore l/g = M/\sigma = x_1/g$, $\therefore x_1 = l$, or deflection due to force equal to weight of structure equals length of pendulum with period of structure. The solution is exact when the mass may be treated as concentrated at centre of inertia, as when structure moves without deformation or rotation, and a close

approximation is obtainable generally by suitably choosing the point at which to measure deflection or assumed distribution of mass. Examples are given.
G. W. DE T.

1383. *Impulsive Thrusts in Pipes formed of Sections having Varying Diameters.* **de Sparre.** (Comptes Rendus, 156. pp. 1521–1528, May 19, 1913.)—In large descents the pipe is often formed of sections where diam. diminishes as the distance from the water intake increases, and in consequence the pressure increases. It might be conjectured that the impulse would not in any case exceed the value which it would have if the pipe had everywhere the diam. of the lower part. The enlargement of the upper section diminishes the kinetic energy of the water confined in the pipe. At a sudden stoppage the above does not apply, and the author gives a mathematical discussion to demonstrate this. The experiments of Allevard are then briefly referred to.
H. H. Ho.

1384. *Experiments on the Flow Process in Divergent and Convergent Channels.* **H. Hochschild.** (Zeitschr. Vereines Deutsch. Ing. 57. pp. 655–662, April 26, 1913.)—Gives the results of an experimental investigation in the form of curves, for which the original pages must be consulted. The channel used was of rectangular cross-section, with interchangeable side plates, and things were so arranged that the pressure at any point on the upper surface of the channel could be measured, as well as the useful energy at any point of the cross-section. An important practical result may be mentioned, namely, that in raising the velocity of flow care must be taken to avoid, in the drop of pressure occurring, that the pressure does not fall much below atmospheric, since each escape of air or water-vapour results in heavy losses owing to the splitting up of the jet in any succeeding velocity-fall. L. H. W.

1385. *Equations for the Dynamical Equilibrium of the Superficial Layer separating one Liquid from another.* **J. Boussinesq.** (Comptes Rendus, 157. pp. 7–13, July 7, 1913.)—The author has already shown [see Abstract No. 913 (1913)], when discussing the motion of a drop of liquid gently falling in a fluid of lower density, that it is necessary to introduce certain viscosity coefficients which are functions of the velocity. He then obtains the equations of motion and shows how they simplify in certain cases, as, for example, for solids of revolution. A. R.

1386. *New Proof of the Formula for the Surface Potential Energy in Perfect Liquids.* **J. Boussinesq.** (Comptes Rendus, 157. pp. 171–176, July 21, 1913.) —Considering only perfect liquids where the two principal surface tensions may be reduced to a single elastic tension, the author by a simple analytical method finds the work done by that tension during an infinitesimal displacement. He points out that the total volume or mass energy of a liquid consists of four parts. First, the kinetic energy, due to the visible motion; secondly, the potential energy due to its weight; thirdly, the potential energy due to the surface tension; and finally, the energy due to the resistance of the fixed boundaries. A. R.

1387. *Savart's Theory of Elastic Liquid Films.* **J. Boussinesq.** (Comptes Rendus, 157. pp. 89–94, July 15, 1913.)—The formulæ due to the author for the superficial viscosity of liquids [see preceding Abstract] either in a transition or a steady state have an interesting application in connection with Savart's theory. They prove the opening out on a little circular horizontal plateau of a vertical descending jet of fluid issuing from a circular horizontal orifice at a low pressure. The author had in 1869 given an approximate solution of this problem. A. R.

1388. *Visibility of Traces of Foreign Substances on the Surface of Pure Water.* **H. Labrouste.** (Comptes Rendus, 167. pp. 44–46, July 7, 1918.)—The study of the properties of extremely thin layers of oil on the surface of water has recently been the subject of an important publication by Devaux. The author of the present paper proposes to show that such layers may be optically discerned by methods involving no special apparatus:—(1) Upon the surface of pure water contained in an ordinary photographic dish, a quantity of oil (triolein) is placed rather less in amount than that corresponding to a monomolecular layer. The dish is illuminated by a Nernst lamp at the side, and the white base of the dish is examined when a jet of compressed air is directed normal to the surface. Here a dark patch is observed, due to the depression of the liquid surface by the jet, surrounded by a brilliant circumference which limits an interior region free from oil. The mechanism is as follows: The gas-jet gives a radial centrifugal movement to the surface, whereby the oil is driven outwards to form a circular peripherical layer, which is sensibly monomolecular and within which are only water molecules. The brilliant circumference is due to the liquid meniscus, whose curvature produces a concentration of light on the floor of the dish. The behaviour of the oil film when the air-blast ceases is discussed in detail. (2) If the oil mass be appreciably less than in the preceding case, the jet is directed obliquely from one of the corners of the dish, and a diffused grey band is seen which advances under the action of the jet; this shadow gradually changes as the oil molecules acquire greater density under the influence of the expulsive jet, and at a certain instant becomes black and suddenly disappears, giving place to a brilliant line; the phenomenon now being that of case (1). The shadow is produced by the uneven surface, exaggerated by local variations of superficial tensions. (3) If the mass of oil be appreciably greater than that corresponding to a monomolecular layer, neither shadow nor brilliant line are observed. (4) Other methods may replace the air-jet, such as the movement of a paraffined thread on the liquid surface, a water-jet normal to the surface, etc. A brilliant line is also recorded when a drop of benzene is placed on the surface. (5) Oils and fats are not the only substances to give the preceding phenomena, *e.g.* certain colloids (gamboge separated from fatty substances by ether extraction), organic liquids such as heptane, ether, turpentine, etc. The author claims the process to indicate instantly the state of a surface at any instant without introducing any disturbing factor. H. H. Ho.

1389. *Sensitive Thermoelectric Manoscope.* **Guéritot.** (Comptes Rendus, 166. pp. 1974–1975, June 30, 1918.)—The principle of the method employed is that very slight displacements of air in a tube connecting two reservoirs may be observed by thermoelectric junctions, if a small section of the air has been previously heated. Since air is displaced for the least difference of pressure between the reservoirs, a manometer of great sensitiveness may be constructed. The tube connecting the reservoirs has a bend made in the middle, the point of the bend being more elevated than the rest of the tube. The air at this point is heated by means of an electric circuit, and since the hot air cannot expand much it remains in the region of the bend. On either side of the hot section two junctions of a thermoelectric couple are stationed, these being connected to a galvanometer. When the air is still, both junctions are at the same temperature, and therefore no current passes through the galvanometer, but any displacement of hot air is recorded by the latter according to the direction of the movement. Experience has shown the manoscope to give very consistent readings, while the galvanometer returns to zero after each displacement. Moreover, the readings are proportional to the volume of gas displaced and record a displacement of 1/10 mm.^{3}. The sensibility may be increased by adding to the number of junctions. The instrument serves to detect sudden gaseous movements, and has permitted the following experiments to be realised: (1) The variation of atmospheric pressure to a millionth of a millimetre of mercury, due to wind-pressure, opening of doors, etc. (2) Sudden variations in wind velocity. (3) The measurement of the energy of very weak electric discharges such as are received by a Hertz resonator placed in a Reiss thermometer. H. H. Ho.

1390. *The Slipping of Liquids at Partitions.* **R. Détrait.** (Comptes Rendus, 156. pp. 1670–1673, June 2, 1913.)—Poiseuille's experiments upon the flow of water in capillary tubes have shown that when the tube is wetted by the liquid there is no slipping of the liquid layer at immediate contact with the wall. Since the time of Coulomb, the existence of slipping when the tube wall is not moistened has generally been accepted. Several experimenters, to which Bénard has been added recently, have shown, by studying the flow of mercury in glass tubes, that if there exists a slipping at the wall this cannot be established by direct measurements; it is stated, however, that the diameters of capillary tubes are not measurable to a sufficient degree of accuracy. To avoid the latter defect the author has compared the flow of two liquids in tubes of glass and sulphur. The liquids used were petrol or alcohol, both of which moisten glass and sulphur, and water which does not wet the sulphur. Directions are given for obtaining suitable sulphur tubes. If P and P′ be the pressures, V the volume of liquid which flows in times T and T′ for water and petrol respectively, then $\eta/\eta' = PT/P'T'$, where η and η' are the respective viscosities. Since viscosity is dependent on temperature, experiments have been made at different temperatures and curves compared. If slipping takes place, the curves will be distinct; if not, the curves will be mixed. In the case of petrol and alcohol, which both wet glass and sulphur, the curves were mixed, but for water they were distinct, and therefore the author concludes slipping to have taken place. Experimental details are given, necessary corrections inserted, and a table of results is appended. The existence of this water slip against a sulphur wall affords the reason of the great e.m.f. obtained by filtering water through sulphur.

H. H. Ho.

1391. *New Method of measuring Fluid Velocity.* **Z. Carrière.** (Comptes Rendus, 156. pp. 1831–1833, June 16, 1913.)—Pitot's tubes, anemometers, and other apparatus for measuring fluid velocity can be rendered very sensitive, but their indications are not always reliable. The usual method consists in displacing the apparatus with a known velocity in a stationary medium. Corrections must be made for air movements if the latter is the medium. In 30 secs. the wind velocity may vary from 1·3 m. to 2·9 m. and its direction change by 30°, so the author asks to what precision the corrections may be taken. He has studied the action of an air current upon an obstacle, the determination of the velocity being made by a novel kinematic method. By a large circular orifice in a thin partition, a vertical jet of air ascends from a suitable reservoir. By a tube of small diam. terminating near the centre of the orifice, a jet of water-vapour under feeble pressure escapes vertically along the axis of the air current. A horizontal beam of light, condensed by a water-filled lens, is projected upon the jet and observations are made in a direction slightly inclined to the incident beam. The vapour-jet vibrates spontaneously; its mass stratified by successive condensations and dilatations, takes the appearance of a set of small isolated clouds which the air current carries away. Individually invisible to the naked eye, the clouds are distinguished from each other by observing them in a mirror which is revolving vertically. Their apparent trajectories are seen in the form of brilliant inclined bands separated by dark intervals. These bands become more vertical the more rapid the air current and the slower the mirror rotation. If ϕ be the angle of the bands with the horizontal, V the speed of the clouds, n the number of mirror revolutions per sec., d the distance of the mirror from the current, then $V = 4\pi n d \tan \phi$. Since the mass of vapour is negligible compared with the mass of air carrying it, it may be assumed that V measures the velocity of the air current. The velocity of the vapour at escape should neither be too great nor too small, the best velocity being that of the air current itself. Usually the air is not dry and the small water-drops have trajectories more horizontal and brilliant than the vapour, so that confusion is impossible. Details are given for determining the angle ϕ, while applications of the method are discussed. H. H. Ho.

1392. *Roughness of Free Liquid Surfaces.* **L. Mandelstam.** (Ann. d. Physik, 41. 8. pp. 609–624, June 24, 1913.)—On the kinetic theory an estimate of the roughness of a liquid surface is obtained, and the scattering of the light calculated. A qualitative experiment confirms the general result of the theory; a quantitative experiment is still needed to test the theory in detail. E. H. B.

1393. *On the Viscosity of the Atom.* **L. Décombe.** (Comptes Rendus, 156. pp. 1598–1601, May 26, 1913.)—Mathematical.

1394. *Influence of Chemical Constitution upon Interfacial Tension. Tension of Composite Fluid Surfaces.* **W. B. Hardy.** (Roy. Soc., Proc. Ser. A. 88. pp. 303–313, and pp. 313–333, May 8, 1913.)—A continuation of previous work [Abstract No. 1805 (1912)] gives further experimental results. L. H. W.

1395. *Ultimate Source of Metals.* **B. Stevens.** (Amer. Inst. Mining Engin., Bull. 75. pp. 331–343, March, 1913.)—The question as to the mode by which metallic aggregates came from the volcanic matrix to the mineral deposits where they are generally found is discussed from the standpoint of the more commonly accepted theories of the constitution of the earth's interior. A number of tables are given showing the temperatures induced in various rocks by different stresses. C. P. B.

1396. *Megaseisms and Lunar Phases.* **de M. de Ballore.** (Comptes Rendus, 156. pp. 100–102, Jan. 6, 1913.)—An analysis has been made of the large earth movements between 1792 and 1899, with comparison tabulations of the lunar phases. The result is that there appears to be no consistent connection between the times of occurrence of the two phenomena. C. P. B.

1397. *Terrestrial Deformation.* **A. Romieux.** (Comptes Rendus, 157. pp. 86–89, July 7, 1913.)—The author in a preceding note (Ibid. vol. 111. pp. 994–996, Dec. 22, 1890) has pointed out that in a terrestrial deformation it is necessary to have equality between five characteristic ratios, of which three were given, viz., S_e/σ_e, where S_e = area of the surface of equideformation and σ_e = the base of the equivolume of primary rocks ; V/B_e, where V = volume of the sea and B_e the equicontinental volume ; and Δ_t/D, where Δ_t = average density of the earth and D = average density of the sea. The present paper is a further mathematical discussion of these ratios. H. H. Ho.

1398. *Periodic Change in the Sea-level at Helder, in connection with the Periodic Change in Latitude.* **H. G. van de Sande Bakhuyzen.** (Konink. Akad. Wetensch. Amsterdam, Proc. 15. pp. 1441–1450, July 15, 1913.)—The author has previously published (1892) a paper on the variation of latitude, deduced from astronomical observations, together with a determination of the change in the mean water-level in consequence of the latitude variation. He assumes the variation of latitude to consist of two parts : a periodic variation which takes place annually, probably due to meteorological influences, and a periodic variation taking place in about 431 days, which depends amongst other things upon the coefficient of elasticity of the earth and its resistance to change of shape. As a consequence of these changes of position of the earth's axis, oscillations of the same periods must take place in the mean sea-level, and if the annual oscillation be eliminated the periodic variation of 431 days remains. The mean sea-level records from 1855–1892 were taken in the previous investigation, and while such variations were found to exist, the changes were so small that the present investigation was undertaken to increase the accuracy of the results. A detailed account of the method of calculation from a large series of observations is then given. The net result is to confirm the opinion that the periodic variation of the sea-level in 431·24 days, as deduced from the observations, is real within the limits of probable error, and that it is a consequence of the latitude variation. The author thinks it of importance to apply similar calculations to other long series of sea-levels, as they might contribute towards the determination of the coefficient of elasticity of the earth.

H. H. Ho.

1399. *Glacial Periods and Terrestrial Polar Fluctuations.* **R. Spitaler.** (Akad. Wiss. Wien, Ber. 121. 2A. pp. 1825–1878, Nov., 1912.)—To explain ice epochs and terrestrial surface-changes, such as are manifested in mountain building, alterations in the distribution of continent and sea, beach movements, etc., repeated changes in the earth's axis of rotation are assumed. The problem arises, whether such alterations have received correct interpretation from a geophysical standpoint. Mistakes can arise by confusing changes of the rotation axis in the earth with those of the chief gravitational axis, etc. It is shown in some exact publications that by geological and meteorological influences mass-changes ensue which shift the gravitational axis and consequently alter that of rotation. These alterations, however, are only small, hypothetical examples being taken for illustration, *e.g.* if the Asiatic central plateau were moved 10° farther south the pole of the gravitational axis would only move 2·76′, *i.e.* 5100 m. The author proposes to investigate the influence of the glacial epoch, during which ice was piled up over Europe and North America, upon the shifting of the various axes. Previous work by Schwahn is referred to with the remark that his conclusions are incompletely developed. The author then proceeds to calculate the effect of ice piling, by assuming that since the ice was due to precipitation of water and moisture from the atmosphere, water must have been withdrawn from the whole earth during the long interval of the ice epoch. Penck and Hergesell's work on the change of earth surface by formation of polar ice and fluctuation in sea-level caused thereby is next dealt with in exhaustive detail, tables being given. In this work, the surface of the North-American and European ice region is divided up by 5 circles, within which uniform distribution is assumed. The weight of the 5 ice cylinders is then calculated, and the conclusion drawn that all the forces tending to change the gravitational pole from its original position act within an angle of approximately 126°. Contemporaneous glaciation on other continents is also examined in great detail. The effect of changes in water distribution is next investigated, and a series of comprehensive tables compiled showing change of gravitational axis with lowering of sea-level. A more exact calculation follows for the shifting of the axis in consequence of ice accumulation in North America and Europe, tables being given embodying the results for different latitudes and longitudes.

The case of polar movements is then examined. After 50 years of stellar observations at Pulkowa, Schiaparelli published a treatise on the rotation of the earth under the influence of geological action, in which several problems concerning terrestrial rotation relations were investigated. In the light of recent observations on polar movements the results require modified interpretation. If the gravitational pole changes according to any given law, the rotational pole traces the Euler curve about it. With uniform motion the curve is a cycloid. This is true, however, only when the earth is perfectly rigid, *i.e.* when both poles cannot separate further. If the earth, however, could adapt itself immediately to the new situation, that is if it were perfectly plastic, then Schiaparelli shows that the Euler movement would be completely suppressed. These relations might have held when the earth was in the early stages of formation, but now being neither quite rigid nor perfectly adaptable the Euler period changes. Thomson, assuming the earth to possess the rigidity of steel, gives 441 days for the Euler period, Newcomb from older observations found 480, and Chandler 427 from later data. The earth, however, while not perfectly adaptable is partially so, and in consequence there will be a movement of the rotation pole. The author investigates the latter by means of his practical data. Radau and Helmert's researches are quoted, in which it is shown that when the gravitational pole undergoes an annual periodic motion, the rotation pole accomplishes one three times as great. Small movements of the gravitational pole may be caused by numerous meteorological processes, and these, according to Milne, Cancani, and Omori, appear to be connected with seismical phenomena. The adaptation constant and the forces brought into existence through pole wandering are then mathematically investigated. In conclusion, a treatise of Ramsay is briefly summarised. The glacial epochs are said to have occurred at intervals when the earth's surface was deformed to its fullest extent, while the tropical periods on the contrary have existed when the continents were almost level. A table is given showing the climatic conditions, and periods of mountain building during the different geological epochs. H. H. Ho.

1400. *Terrestrial Gravity and Earth Movements.* **J. W. Spencer.** (Amer. Journ. Sci. 85. pp. 561–578, June, 1913.)—The deformation of the North American lake regions by subsidence is not due to a removal of the ice, but to an unequal warping resulting from differential sinking of areas resting on foundations of unequal rigidity. The submarine valleys or cañons dissecting the platforms or terraces on the edge of the continental mass demonstrate great subsidence of the land, or rise of the ocean-level, in very late geological times. Correspondingly, almost everywhere a deficiency of gravity characterises the continental border, and often extends far inland among the mountains themselves. This is illustrated by maps. E. E. F.

1401. *Determination of Geoids in the Harz District.* **F. R. Helmert.** (Preuss. Akad. Wiss. Berlin, Ber. 28. pp. 550–560, 1913.)—The author explains the term "Geoid" as a level surface (gravitational), which at sea-level passes beneath the continental surface. The method of estimation employed was by the usual astronomic-geodetic determinations, whereby plumb-line deviations are established. From these, more or less exact conclusions may be drawn as to the shape of the geoids. The latter give valuable information as to the disturbance due to masses of the earth's crust below sea-level. On account of the curvature of the plumb-line, a large number of gravity determinations were made over the district examined. The author gives an historical review of previous work, followed by a detailed description of the stations where his own measurements have been made. A table of results is given for the meridian of the Brocken, and their nature fully discussed. H. H. Ho.

1402. *Relations between the Different Phenomena of Solar Activity.* **A. Riccò.** (Accad. Lincei, Atti, 22. pp. 815–823, June 15, 1913.)—As a result of some thirty years' observations, considered in conjunction with those published by other observers, it is concluded that maculæ, faculæ, eruptive protuberances, and filaments all have their seat in the zone of the maculæ, and are intimately interrelated both in position and origin. The hydrogen prominences and filaments are emission and absorption images respectively, of the same solar objects, and have no close connection with either maculæ or faculæ. The solar corona is related to the maculæ, and even more closely to the prominences. All solar phenomena follow the undecennial cycle of solar activity, and present corresponding phases of development. W. H. Si.

1403. *General Magnetic Field of the Sun.* **H. Chrétien.** (Comptes Rendus, 156. pp. 192–194, Jan. 20, 1913.)—Assuming that the sun rotated as a whole, the form of its general magnetic field would correspond to that of an infinitely short magnet on the axis of rotation, and at the centre. This must be modified to take account of the known variations of rotation of different regions of the solar surface, and formulæ are developed including terms for expressing the new conditions. Values are given of the deduced field for intervals of 15° in latitude, and these are to be compared with any experimental determinations which may become available in future. [See also Abstract 367 (1913).] C. P. B.

1404. *Magnetic Fields at the Solar Surface.* **Gouy.** (Comptes Rendus, 156. pp. 512–515, Feb. 17, 1913.)—Discussion of several points of view for considering the production of magnetic fields comparable to those recently found existing in the neighbourhood of sun-spot vortices. C. P. B.

1405. *Variability of the Pole Star.* **A. Pannekoek.** (Konink. Akad. Wetensch. Amsterdam, Proc. 15. pp. 1192–1199, May 30, 1913.)—From observations made in 1889–90 evidence was found for considering the magnitude to vary throughout a short period of about 4 days. The later investigations of spectroscopists also indicated variation in the radial velocity, and this led the author to make a more complete reduction of his observations. He finds the variation to be about 0·057 mag. with a period of 3·96809 days. C. P. B.

1406. *Spectrum of Comet Quénisset* (1911*f*). **G. Zappa.** (Accad. Lincei, Atti, 22. pp. 886–892, June 15, 1913.)—Photographs of the spectrum of comet Quénisset [Abstract No. 1447 (1911)] show it to be continuous between λ = 385 and λ = 500, and to have bands corresponding with cyanogen and carbon. W. H. St.

1407. *Distribution of Spectroscopic Double Stars.* **P. Stroobant.** (Comptes Rendus, 156. pp. 37–39, Jan. 6, 1913.)—It has been shown by E. Zinner that variable stars of the Algol type are notably condensed in the neighbourhood of the Milky Way. Taking Campbell's 1910 list of spectroscopic binaries, the present writers discusses their distribution with respect to various zones of galactic latitude, the results showing a very marked correspondence.

C. P. B.

1408. *Spectra of Nebulæ.* **J. Meunier.** (Comptes Rendus, 156. pp. 891–893, Feb. 3, 1913.)—The wave-lengths of the principal nebular lines, other than those recognised as due to hydrogen, are compared with those of the nearest lines of the spectra of iron and titanium, and the suggestion is made that they may be due to the flame spectra of these substances under special conditions. The wave-lengths of lines taken as identical are very discordant in many cases. [See also Abstracts Nos. 945 (1910), 901 (1911), 457 (1913).]

C. P. B.

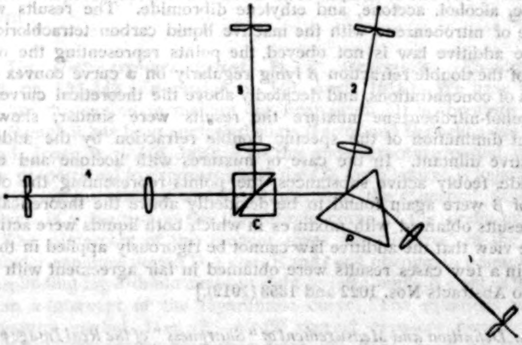
LIGHT.

1409. *Spectroscopic Camera for Projection.* **A. J. Bull.** (Photographic Journ. 58. pp. 175–179; Discussion, pp. 179–180, May, 1918.)—The instrument is an ordinary spectroscope with an auxiliary lens similar to the colour-patch apparatus of Abney. A photographic objective is placed so that the slit is at its principal focus. Perpendicular to the axis of the slit is placed a replica of a diffraction grating, and the spectrum used is the first order on the one side. In order to bring that to a focus a second photographic objective is placed in position so that its axis corresponds to about the mean ray of the first order of spectrum on one side, and at the principal focus of this objective there is formed the real spectrum. The whole arrangement is boxed in, and great precautions are taken to avoid stray light. Owing, however, to a certain inevitable amount of scatter at some of the surfaces, particularly of the grating replica, it has not been possible to eliminate all the scattered light. The instrument is used for the study of a number of points in photomechanical work, such as the comparative properties of orthochromatic plates, and the principles underlying three-colour printing. In order to demonstrate the colour-sensitiveness of a photographic plate the slit is illuminated by the light from an arc light, the condenser being removed and the plate exposed to the spectrum. From the resulting negative a positive is made upon a lantern plate by contact. This is fixed in a frame, so that it can be replaced in the spectrum in correct register. On projecting an image of this, the only light which reaches the screen is that which the plate under test recorded, and so the colour-sensitiveness of the plate is visualised. In order to show the maxima and minima of the sensitiveness of the plate to better advantage, a wedge of neutral-tinted glass is placed over the slit while making the exposure. The negative then shows the curve of sensitiveness of the plate under these conditions, and so the projection of the positives brings out more vividly the varying sensitiveness of the plate to the components of the spectrum. The use of the instrument in teaching the principles of three-colour work is also discussed. A. E. G.

1410. *Microphotometer for Photographic Density Measurement.* **H. Buisson** and **C. Fabry.** (Comptes Rendus, 156. pp. 389–391, Feb. 3, 1913.)—Utilising the general principle of equalising the opacity of the unknown density with that of a standard plate of gradated density, an instrument has been constructed allowing of a very accurate examination of any desired small area. The illumination of standard and unknown is furnished from the same source to avoid disturbance due to variation of the light. The light first passes through a small diaphragm, from 1 to 2 mm. diam., placed at the focus of a lens. By means of reflection prisms and suitable lenses the beam is carried in two separate portions, one through a Lummer-Brodhun cube, the other reflected by a similar cube, and the two resulting images may be superposed. The standard scale of densities is inserted in the path of one beam, and the plate to be measured in the other. For densities of similar nature to the standard, white light is employed; while for cases where the deposits are different in colour green light is used from a screened mercury arc.

C. P. B.

1411. *New Precision Colorimeter.* **P. G. Nutting.** (Bureau of Standards, Bull. 9, pp. 1-5, March 15, 1913.)—The colorimeter here described is a monochromatic analyser, and was designed to be a practical working instrument of wide range, high precision, and of great simplicity. It is so arranged that light of a pure spectral hue may be mixed with white light to match the unknown; or, in the case of purples, it is mixed with the unknown to match white. The match is made with a photometer cube. In the Fig., collimator 1 is movable; all the remaining parts are fixed. Collimators 1 and 4 with prism P form an ordinary spectroscope with pinhole ocular. The white and the unknown lights enter through collimators 2 and 3, in direct or in inverse order, according as the match is to be made with the dominant hue or its complementary. In analysing reflected light the necessary collimator is raised or rotated or even removed entirely if sunlight is used. Wave-lengths are varied simply by rotation of collimator 1. Intensities may be varied by (i) varying slit widths, (ii) rotating sectors, or (iii) by rotating one of a pair of nicols placed just inside each slit. After a match has been secured, the wave-length of the dominant hue is either read from the position of collimator 1 or is determined by throwing in a small hand spectroscope before the pinhole ocular of 4. Intensities are determined by interposing between collimator 4 and photometer cube C, a white 180° (Whitman) rotating disc illuminated by a standard lamp. This gives the intensity in candle-metres of each of the three component beams separately. A photograph of the instrument is reproduced, and several sets of data are given to show the sensibility of the instrument and the systematic errors to which the readings are subject. [See also Abstracts Nos. 1493 (1907) and 228 (1908).] A. W.



1412. *Interferential Strioscope.* **G. Sagnac.** (Comptes Rendus, 156. pp. 1838-1840, June 16, 1913.)—The author has previously described [Abstracts Nos. 1218 (1912) and 1262 (1913)] an interferential arrangement which gives on a dark field bright images of very slight disturbances of homogeneity of the medium traversed by the light. By utilising the light first transmitted and finally transmitted, an interferometer arrangement is obtained which gives a central white fringe, and which can be transformed into a strioscope by enlarging the central fringe, thus obtaining a uniformly bright field. If the double prism with air film is replaced by a glass plate partly silvered on one side, there is little loss of luminosity. This arrangement yields a second set of fringes with a white centre. By removing the silvering from one half of the plate there is obtained, for a sufficient thickness of silver, a bright and a dark field side by side, giving a double image of a disturbed region geometrically symmetrical with respect to the line of separation but of complementary colours. A. W.

1413. *Magnetic Double Refraction of Liquid Mixtures.* **A. Cotton** and **H. Mouton.** (Comptes Rendus, 156. pp. 1456–1459, May 19, 1913.)—Experiments were made with a view to ascertaining whether magnetic double refraction of liquid mixtures is or is not an additive property. The experiments were carried out with mixtures of nitrobenzene with carbon tetrachloride, alcohol, acetone, and ethylene dibromide. The results with the mixture of nitrobenzene with the inactive liquid carbon tetrachloride show that the additive law is not obeyed, the points representing the observed values of the double refraction β lying regularly on a curve convex towards the axis of concentrations, and decidedly above the theoretical curve. With the alcohol-nitrobenzene mixture the results were similar, showing an apparent diminution of the specific double refraction by the addition of an inactive dilutant. In the case of mixtures with acetone and ethylene dibromide, feebly active substances, the points representing the observed values of β were again found to be decidedly above the theoretical curve. Other results obtained with mixtures in which both liquids were active confirm the view that the additive law cannot be rigorously applied in this case, though in a few cases results were obtained in fair agreement with theory. [See also Abstracts Nos. 1022 and 1853 (1912).] A. W.

1414. *Definition and Measurement of "Sharpness" of the Real Image produced by Dioptrical Instruments.* **U. Bordoni.** (N. Cimento, 5. Ser. 6. pp. 227–254, April, 1913.)—If in the plane of projection of a photograph there are two differently illuminated regions, sharply separated by a line, the image will also consist of two unequally illuminated portions, separated however by a hazy space, and the clearness or "sharpness" v of a photographic image, at a point K, and in a generic direction l, is defined as the reciprocal of the width λ (measured in mm.) of this cloudy space, when the axis of the latter is normal to the direction l, and the passage from the more illuminated to the less illuminated region is in the direction l. Supposing the two regions to rotate around K, the value of v can be determined in every direction. The measurements of λ are best made directly by means of a microscope. W. H. Si.

1415. *Birefringence of the Cortical Substance of Animal Hairs.* **A. Pochettino.** (Accad. Lincei, Atti, 22. pp. 496–502, April 20, 1913.)—The specific birefringence of the cortical substance of hair is not constant, but differs from hair to hair, and for the same hair, from point to point, having a max. value about half-way up the hair from its base, and being greater the smaller the diam. of the hair, and consequently increasing with rise of temperature. Immersion in various liquids—water, alcohol, ether, glycerine, xylol, clove oil, etc.—causes variation of the birefringence, but no relation can be established between the refractive index of the liquid and the variation observed in the birefringence. Immersion in H_2O_2 slightly increases the birefringence, and dipping in KOH solution greatly reduces it, while treatment with HNO_3 at 60° reduces it to zero. Of the three possible explanations of the birefringence (1) natural birefringence, (2) accidental birefringence due to elastic deformation, or (3) lamellar birefringence, the last is considered the most likely. W. H. Si.

1416. *Photographic Photometry.* **D. A. Goldhammer.** (Phys. Zeitschr. 14. pp. 888–894, May 1, 1913.)—Describes a method based upon that of König and Martens [Abstract No. 507 (1904)] but introducing a Babinet compensator in such a manner as to give two systems of fringes, one adjoining the other. These can be photographed, and by means of a micrometer microscope the points at which the line of demarcation between the two systems disappears are determined. These are the points of equal intensity, and their position depends upon the relative illuminations of the two portions of the biprism. E. E. F.

1417. *The Under-exposure Period.* **F. F. Renwick.** (Photographic Journ. 53. pp. 127–142; Discussion, p. 142, April, 1913.)—We have in any event to use this period in making our final print. It is therefore of importance, though it has been neglected since Hurter and Driffield's work (Soc. Chem. Ind., Journ. 9. p. 455, 1890). In the under-exposure period, density is linearly proportional to exposure; and the (D, log E) curve is logarithmic. This always merges without a discontinuity into the "correct exposure" curve, which is a tangent to the logarithmic curve of the under-exposure period. The x-intercept of this tangent gives the "inertia" of the plate. If in the under-exposure period $D + c = \mu E$ and $c = 0$, changes in u simply shift the corresponding logarithmic curve to right or left; while if c not $= 0$, there will be an x-intercept of the logarithmic curve. The equations are: (1) Under-exposure period, $D = uE - c$; (2) correct exposure period, $D = \gamma(\log E - \log i)$; (3) at the transition point (E_1, D_1), $\gamma = (D_1 + c) \log_e 10$, $\log (E_1/i) = 0{\cdot}4343 - (c/\gamma)$, and $\log (\gamma/u) - 0{\cdot}7965 + (c/\gamma) = \log i$. Hurter and Driffield's (D, log E) curve indicates, for equal times, equal increments of ordinates; and these indicate equal variations in the visible brightness of the light or in the visible want of transparency in the deposit. Truthful representation in the final print is favoured by having the scale of opacities in the negative follow a logarithmic rather than a straight curve. This justifies the ordinary practice of under-exposing for portraits. Increasing the time of development increases γ, makes the tangent steeper, shifts the logarithmic curve to the left, but does not change the x-intercept of the tangent. Within the under-exposure period it is therefore possible (so long as c remains the same though γ changes) to get the same gradation by a shorter development of a more fully exposed plate or by the longer development of a less fully exposed plate. If E_0 be the least exposure giving a developable impression and E_1 the max. exposure within the "under-exposure" period, $E_1/E_0 = 0{\cdot}4343\gamma/c$. If u_∞ be the limiting value of the development constant, and E the shortest exposure which will yield any given density D(= log. opacity), we have $E = (D + c)/u_\infty$; here in positive printing processes c is rarely greater than 0·1, and D is from 1·9 to 2; so that $E = 2/u_\infty$, which may be taken as an "exposure number" representing the candle-metre-seconds required to make a good transparency from an average negative. About half this exposure would be required for a print on paper coated with the same emulsion. The relation between the real densities of deposit and the apparent blacknesses when backed by white opal in optical contact gives a curve whose slope is at first steep and first gradually, then more rapidly, falls off, verging towards the horizontal. The range of contrast by reflection is not more than 1 : 30 with white opal, and is less with white paper. A. D.

1418. *Constancy of the Velocity of Light.* **W. de Sitter.** (Phys. Zeitschr. 14. p. 429, May 15, 1913. Konink. Akad. Wetensch. Amsterdam, Proc. 15. pp. 1297–1298, July 15, 1913.)—Shows that if the velocity of the source is added to the velocity of light (Ritz) the half-swing of a binary star will take a time $T + 2u\Delta/c^2$ in one direction across the line of sight, and $T - 2u\Delta/c^2$ in the other direction, u being its orbital velocity, Δ its distance, and c the velocity of light. The other theories make the second term zero. In many binaries it is of the same order as T, as, when T is 8 days, u is 100 km./sec., and Δ 33 light years. If, therefore, the velocity of the source were added to that of the light, the motions observed would not obey Kepler's laws. But radial velocities, coupled with observations of resolvable binaries and Algol variables, show no deviation from Kepler's laws. The conclusion is that the velocity of light is constant. E. E. F.

1419. *Optical Properties and Physical Constitution of Water.* **C. Chéneveau.** (Comptes Rendus, 156. pp. 1972–1974, June 30, 1913.)—Röntgen's hypothesis, developed by Duclaux and Piccard, attributes to water a complex constitution for explaining the variation of some physical properties with temperature. Briefly, water is assumed to be made up of two different substances, either in association or mixture, one of which is analogous to ice and whose quantity diminishes with increasing temperature. The author has investigated this hypothesis to see if it is in accord with the variation in the optical properties of water. According to Piccard the proportion of ice at 0° C. in water is 29·1 per 100, while at 100° C. this is reduced to 1 per 100. In the following discussion the author assumes Piccard's results. Since the ordinary refractive index for ice is very near its extraordinary index, the author adopts an average μ of 1·3095. The specific refractive powers for water and its supposed constituents, viz. ice and hydrol (so termed by Sutherland), are calculated at 0° C. and 100° C. according to the formulæ of both Gladstone and Lorentz. The results were found to be in accord with the above mixture hypothesis. A remarkable feature of the latter hypothesis is that it makes no modification for the optical properties of aqueous solutions, even when admitting that at a given temperature the proportion of ice diminishes with the amount of salt dissolved (Duclaux and Wollmann). Data are given for solutions of potassium chloride to illustrate this point. H. H. Ho.

1420. *Absorption, Dispersion, and Fluorescence of Light.* **B. Söderborg.** (Ann. d. Physik, 41. 2. pp. 381–402, June 3, 1913. Communication from the Physikal. Inst., Stockholm.)—Describes research with eosin, fluorescein, and erythrosin solutions on the relation between absorption, dispersion, and fluorescence of light. The results agree well with the Ketteler-Helmholtz dispersion formulæ. A. W.

1421. *Hartmann Objective-testing Apparatus.* **H. Fassbender.** (Zeitschr. Instrumentenk. 33. pp. 177–188, June, 1913. Communication from the Physikal.-Techn. Reichsanstalt.)—Three methods of use of Hartmann's apparatus are briefly outlined [see Abstract No. 2361 (1904)] and the last two of these are compared. It is seen that sometimes one, sometimes the other, may be used with advantage. A. W.

1422. *Absorption of Light in Heterogeneous Media.* **P. G. Nutting.** (Washington Acad. Sci., Journ. 8. pp. 322–326, June 4, 1918.)—A treatment of the problem of the absorption of light by silver grains embedded in a photographic film by means of the methods of the theory of probability.

J. J. S.

1423. *Luminosity Curves of Persons having Normal and Abnormal Colour Visions.* **W. Watson.** (Roy. Soc., Proc. Ser. A. 88. pp. 404–428, June 2, 1913.)

1424. *Modern Developments in Bank-note Printing necessitated by Recent Advances in Photography.* **A. E. Bawtree.** (Photographic Journ. 58. pp. 167–172; Discussion, pp. 172–175, May, 1918.)—The original pages should be referred to for the account of the author's method of producing designs without geometrical work and repetitions, and which are practically impossible to reproduce by the usual building-up methods used by counterfeiters. The paper is of importance for those interested in engraving and process work. L. H. W.

1425. *Paget Colour Plate.* **G. E. Whitfield** and **C. L. Finlay.** (Photographic Journ. 58. pp. 142–145; Discussion, pp. 145–148, April, 1913.)—Explanation and demonstration; minute coloured squares on a taking screen; Paget panchromatic plate exposed through this and developed; positive transparency made and bound up in register with a corresponding viewing screen. Any number of copies may be made; pictures bright and luminous. Method described for producing colour pictures on paper; a transfer method, incorporating a very pale screen in the finished picture. A. D.

1426. *Relation between Luminous Energy and Photochemical Action.* **A. Tian.** (Comptes Rendus, 156. pp. 1601–1604, May 26, 1913.)—A theoretical consideration.

1427. *Elliptically Polarised Light.* **L. Chaumont.** (Comptes Rendus, 156. pp. 1604–1606, May 26, 1913.)—An algebraic theory of apparatus suitable for the study of elliptically polarised light has been given by Tuckerman; in the present paper it is shown how the geometrical representation of Poincaré can be employed to use this theory in a simple and general manner. A. W.

1428. *Variation of Magnetic Rotatory Power during Changes of State.* **J. Chaudier.** (Comptes Rendus, 156. pp. 1529–1532, May 19, 1913.)—Becquerel's experiments with carbon disulphide, and Bichat's with sulphur dioxide, have shown that the magnetic rotatory power of these bodies in the gaseous state is less than the calculated value, assuming the molecular magnetic rotatory power to be retained during vaporisation. The author's experiments upon the magnetic rotatory polarisation of the liquefied gases oxygen, nitrogen, CO_2, and SO_2, led him to compare the values for the liquid and gaseous states. Experiments have also been made during changes of state from active liquids to solids. A table is given embodying the experimental results. The values calculated are based on the assumption that the molecular magnetic rotatory power is invariable. The determinations were made at the boiling temperatures and under atmospheric pressure. The author concludes that in the passage from liquid to solid state the rotatory magnetic power of these active substances is preserved if the liquid on congelation gives rise to an amorphous body of vitreous aspect, while it totally disappears if a crystalline structure be acquired. As examples of the former, essence of turpentine, amylalcohol, and glycerine are quoted, while of the latter, aniline, nitrobenzene, benzene, carbon disulphide, and ethyl alcohol are cited. Analogous observations have been made by Biot and Gernez on the variation of ordinary rotatory power on fusion or solidification. The magnetic rotatory power of active substances in the gaseous state, calculated on the assumption that the phenomenon varies as the density, is always higher than that directly observed, although in some cases almost equal to it. Thus, while ordinary rotatory power is preserved in the passage from liquid to gaseous states, the magnetic rotatory power generally diminishes, and for certain bodies may become less than half. Moreover, there appears to exist a relation between this variation and the magnetic rotatory dispersion law for active substances. H. H. Ho.

1429. *Goldstein's Method and Spectra of Air, Nitrogen, and Oxygen.* **J. Scharbach.** (Zeitschr. wiss. Phot. 12. pp. 145–188, May, and pp. 189–206, June, 1913.)—The following spectra were investigated :—(i) Spectrum of the spark in air, and the spectra of air, nitrogen, and oxygen in Geissler tubes; (ii) Spectra of the haloid compounds, principally of the alkalies, in Geissler tubes. From (i) it appears that the spark discharge in nitrogen, oxygen, or in air gives rise to similar spectra to those obtained with Geissler tubes filled with the same substances. From (ii) it is shown that most of the lines which Goldstein designates lines of the "Grundspectra," are not new lines, but known lines of the spark spectra. A. W.

1430. *Distribution of Intensity within a Spectrum Line.* **W. Voigt.** (Phys. Zeitschr. 14. pp. 377–381, May 1, 1913.)—Examines the distribution of absorption in the case of the red lithium line and the two yellow sodium lines, both according to the electron theory and the photographs of Richter and Ivanoff. If the incident energy is I, the energy emerging from the absorbing flame is Ie^{-p}, where $p=\frac{4\pi}{\lambda}\int n\kappa dz$, the integration extending over the thickness of the flame. The quantity p is best given by the formula—

$$p=\bar{p}\left[\left(\tan^{-1}\left\{a/(\mu^2-b)\right\}/\tan^{-1}(a/-b)\right],$$

but some alternative formulæ are given. E. E. F.

1431. *Measurements of Wave-lengths in Spectrum of Iron.* **K. Burns.** (Comptes Rendus, 156. pp. 1611–1613, May 26, and pp. 1976–1978, June 30, 1913. Journ. de Physique, 3. Ser. 5. pp. 457–467, June, 1913.)—Using the method of Buisson and Fabry and étalons of thickness 2·5, 5·0, and 7·5 mm., photographic determinations were made of the wave-lengths of 125 lines in the spectrum of the iron arc, the wave-lengths ranging from 5434·529 to 8824·254. The wave-lengths of these lines are given. The use of interferences obtained with many different values of path-difference allowed the effect of change of phase by reflection to be eliminated. A. W.

1432. *Wave-length Measurements.* **H. Kayser.** (Zeitschr. wiss. Phot. 12. pp. 296–307, July, 1913.)—A paper discussing the present position of wave-length measurements. Second-order normals from interferometer measurements in the arc spectrum of iron are noted, also third-order normals from grating measurements in the same spectrum. A list is given of measurements, in International units, of wave-lengths of a number of other elements. A. W.

1433. *Helium Spectrum.* **E. Goldstein.** (Deutsch. Phys. Gesell., Verh. 15. 10. pp. 402–412, May 30, 1913.)—Describes, with photograph, a number of new lines in the He spectrum. The tubes used were of the end-on variety, and the new spectrum was obtained with He derived from many different sources. [See also Abstract No. 2034 (1907).] A. W.

1434. *Band Spectrum of Barium Fluoride and Barium Lines.* **H. George.** (Zeitschr. wiss. Phot. 12. pp. 237–258, July, 1913. Extract from Dissertation, Bonn.)—Deals at length with the band spectrum of BaF_2 in the electric arc. Wave-length tables of the lines in the different bands are given, and the constants in the Fabry formula, $N = A + (mB \pm C)^2$, are calculated for each band. Measurements of the Ba lines in International units are also given from λ7059 to λ8210. A. W.

1435. *Normal Wave-lengths in Arc Spectrum of Iron.* **F. Goos.** (Zeitschr. wiss. Phot. 12. pp. 259–275, July, 1913.)—A further contribution towards the establishment of normal systems of wave-lengths in the arc spectrum of iron. [See Abstract No. 60 (1913).] A. W.

1436. *Arc Spectrum of Iron.* **K. Burns.** (Zeitschr. wiss. Phot. 12. pp. 207–235, June, 1913.)—The author has previously given the results of measurements of the wave-lengths of a number of lines in the arc spectrum of iron between λ5434·529 and λ8824·254 (Abstract No. 1431 (1913)]. The present paper deals with the lines of wave-lengths between λ5434·527 and λ2373·624. Using Abney's method with a Rowland concave grating, accurate measurements were made of the wave-lengths of about 2500 lines; these are tabulated with intensities and probable errors. In addition, lines of Mn between λ2593·732 and λ4823·524, of Ni between λ3002·488 and λ3619·392, and of various elements between λ2795-542 and λ5208·429 are given. A. W.

1437. *Arc Spectrum of Platinum.* **E. Symons.** (Zeitschr. wiss. Phot. 12. pp. 277–295, July, 1913. Extract.)—Using the Rowland concave grating of the Physikal. Inst. of Bonn, the arc spectrum of Pt was photographed. Wave-length tables are given from λ6710·44 to λ2144·19 I. units, and include for comparison the results of Rowland and Tatnall, Exner and Haschek, and Kayser. A. W.

1438. *Dispersion of Fluorite in Infra-red.* **F. Paschen.** (Ann. d. Physik, 41. 3. pp. 670–672, June 24, 1913.)—Using the same fluorite prism as in earlier work, the dispersion was redetermined for the spectral region from 1 μ to 2 μ, using the same method as for a quartz prism, previously described [Abstract No. 1479 (1911)]. Hg and He lines were employed. A. W.

1439. *Simplification of Spectral Lines by Magnetic Field.* **R. Fortrat.** (Comptes Rendus, 156. pp. 1459–1461, May 13, 1913.)—Various experimenters have shown that in very strong magnetic fields certain groups of spectral lines are simplified [see Abstracts Nos. 867 (1912); 68, 1282 (1913).] In the present paper the author describes the action of a magnetic field on certain band spectra, and shows that a large number of naturally multiple lines are simplified by the action of the field, in this case of 40,000 gauss. A diagram is given of the effect on the green band of carbon. The action of the field reduces all the doublets to simple lines, and the triplets are also reduced to simple lines for all frequencies above 1949. The blue band of the Swan spectrum gave similar results, as also did the spectrum of the negative pole of nitrogen. The phenomenon thus appears to be a general property of band spectra. A. W.

1440. *Magnetic Normal Triplet and Preston's Law.* **R. Fortrat.** (Comptes Rendus, 156. pp. 1607–1609, May 26, 1913.)—Paschen and Back have shown that the oxygen triplet λ3947 gives, in a field sufficiently intense, a magnetic triplet very closely approximating to the normal [Abstract No. 1282 (1913)]. The present paper describes a similar research with the sodium doublet λ2852·828, 2853·031. In a weak field the decomposition follows Preston's rule. In a field of 34,400 gauss two anomalies present themselves. These are described with the aid of a diagram. With a field of 44,500 gauss most of the regular components could be distinguished, but with very abnormal intensities and polarisations, and with displacements considerably greater than the errors of observation. In a field of 47,600 gauss, in place of the 10 components given by Preston's rule, only a triplet is found; the side component on the short wave-length side is sharp, the central component and the other side component being broader. Measurements of the distances between the sharp line, the most intense part of the central line, and the middle of the other side line show that the triplet is nearly normal. It appears probable that a field of 50,000 gauss would give an exact normal triplet with sharp components. The author has previously shown that in certain bands the doublets and triplets are reduced by a magnetic field to a single line [see preceding Abstract]. This fact throws some light on the present results, since it now appears that both a doublet and a triplet behave, in sufficiently strong fields, as if formed of a single line. A. W.

1441. *Zeeman-effect.* **W. Voigt.** (Ann. d. Physik, 41. 2. pp. 403–440, June 3, 1913.)—A lengthy paper giving a mathematical treatment of the Zeeman-effect, with special reference to the simplification of the Zeeman-effect in the case of groups of lines, as found by various investigators [see Abstracts Nos. 419, 806 (1913), and two preceding Abstracts.] A. W.

1442. *X-ray Fluorescence.* **W. Kaufmann.** (Phys. Zeitschr. 14. pp. 387–388, May 1, 1913.)—Describes an apparatus for demonstrating Barkla's homogeneous secondary X-rays. Rays from the antikathode fall through a hole in a lead screen, closed with black paper, on to a row of squares of various metals. The secondary X-rays emitted by these fall back upon a fluorescent screen affixed to the lead screen and perforated to admit of the passage of the primary rays. The fluorescence is observed through the intervals between the metallic squares. At 12,000 volts, the metals Fe, Cu, and Zn give the fluorescent radiation, while Al does not, neither do the heavier metals. A mica strip pasted on the fluorescent screen appears nearly black in the rays from Fe, but grey in those from Zn. The absorption therefrom decreases rapidly with increasing atomic weight. The fluorescent rays are softer than the primary rays, thus obeying Stokes' rule. Pt and Pb only show the softer radiation (Barkla's L-rays). The K-rays have not yet been found in their case. E. E. F.

1443. *Radio-activity of Hot-spring Sediments.* **M. Hayakawa** and **T. Nakano.** (Kyōtō Coll. Sci. Engin., Mem. 5. pp. 137–146, March, 1913.)—The experiments show that the sediments of the springs at Hokuto, Taiwan, which contain 32 % BaO, also contain measurable quantities of radium, polonium, and ionium. E. M.

HEAT.

1444. *An Anethol Calorimeter.* **U. Grassi.** (Accad. Lincei, Atti, 22. pp. 494–495, April 20, 1913.)—The author has devised a vacuum-jacketed modification of the Bunsen calorimeter, in which other substances than water or ice may be employed. The present paper deals with its use with anethol, which melts at 21·55° C., and furnishes a very sensitive calorimeter, a small calorie corresponding to 0·0345 gm. Hg, whereas in the case of ice it corresponds to only 0·0154 gm. A determination by its means of the water equivalent of a block of electrolytic copper has given 3·78 gm. between 0° and 21·55°, and 3·81 gm. between 21·55° and 34·9°. W. H. Si.

1445. *Note on the Specific Heat of Diatomic Gases.* **P. Ehrenfest.** (Deutsch. Phys. Gesell., Verh. 15. 11. pp. 451–457, June 15, 1913.)—Eucken [see Abstract No. 517 (1912)] had observed that hydrogen behaves practically like a monatomic gas below 60° K. To account for this observation Einstein and Stern [Abstract No. 1016 (1913)] suggested that the rotating molecule was a Planck resonator of variable frequency ν, and that the molecule (dipole) had at absolute zero the kinetic energy $h\nu/2$, in accordance with Planck's second formula for the energy as function of the absolute temperature. This assumption would make the tangent to the c_R curve (the curve of its energy component of the specific heat due to the rotation about one axis) horizontal (and not vertical, as Planck's first formula would) for $T = 0$, as it should be according to Eucken's observations. The demand by Einstein and Stern of a definite ν for each T requires, however, a statistical correction, as they pointed out themselves. The author hence deduces another way of calculating the c_R, which is statistically consistent throughout; he assumes that the kinetic energy is always an integer multiple of $h\nu/2$, and makes a further assumption as to the orientating field. The deduction is carried out first for one and then for two rotational axes. The resulting c_{2R} curve has an initial maximum at about 550° K., and afterwards approaches its equipartition value asymptotically, whilst Einstein's curve and the c_v curve show no initial maximum. H. B.

1446. *Viscosity of Gases at Low Temperatures.* I. *Hydrogen.* II. *Helium.* III. *Comparison of the Results Obtained, with the Law of Corresponding States.* **H. Kamerlingh Onnes, C. Dorsman,** and **S. Weber.** (Konink. Akad. Wetensch. Amsterdam, Proc. 15. pp. 1386–1403, July 15, 1913. Communications, Nos. 134*a*, 134*b*, 134*c* from the Phys. Lab., Leiden.)—The investigation of the dependence of the viscosity of gases upon the temperature at densities near the normal is chiefly of importance for acquiring knowledge of the mechanism of the impact of two molecules, or, in monatomic gases, of two atoms. The authors extend such an investigation with one substance over the largest possible range of reduced temperature. In the field of hydrogen temperatures the authors found the viscosity of hydrogen, while flowing through a capillary tube, to be dependent upon the mean pressure. Now Maxwell has established that the viscosity of gases at normal density is independent of the pressure, and Warburg and v. Babo have shown that in dense vapours it increases with the density, therefore the dependence of viscosity upon pressure in hydrogen vapour is worthy of thorough investigation. The measurements were made according to the transpiration method, and the paper contains a detailed account of the principles involved and the arrangement of the apparatus. Tables of results and explanatory curves are given. The viscosity was found to change with the density, and in the same direction as found by Warburg and v. Babo for CO_2. The same investigation with respect to helium was carried out by Onnes and Weber, and no such dependence on density found as in the case of hydrogen. The results are compared with those obtained by Schierloh and Schmitt, and correspond very well. The empirical formula $\eta/\eta_0 = (T/278{\cdot}1)^{0{\cdot}647}$ is found to agree remarkably well with the values obtained over the whole extensive field of temperatures. The authors then discuss their results from the standpoint of the various formulæ relating to the dependence of viscosity on temperature. Those of Sutherland and Reinganum are found to be quite inapplicable, as well as a suggested empirical correction by Rappenecker. None of the formulæ deduced from theoretical suppositions represents the observations for helium, and for the present only the authors' empirical representation can be used, which for hydrogen also holds better at lower temperatures than the theoretical ones. Finally, an application of the principle of mechanical similarity upon the comparison of the viscosities in corresponding conditions is made.

H. H. Ho.

1447. *Absorption by Water-vapour, and New Groups of Residual Rays in the Region of Long Wave-lengths.* **H. Rubens.** (Preuss. Akad. Wiss. Berlin, Ber. 28. pp. 513–549, 1913.)—The extent of the influence of the particular light-source, and of the number of reflections on the average wave-length and spectral composition of the residual radiation, has been previously studied by the author for fluorite, and later for rock-salt and sylvin by Hollnagel. The results given were, that these influences were opposed to those of selective reflection by the surfaces in all cases investigated. Also, as the author establishes later, the energy of the residual radiation is strongly influenced by the selective absorption of the water-vapour in the room air, so that the appearance of two maxima in the intensity curves for rock-salt, sylvin, and potassium bromide must be ascribed to absorption by water-vapour. The author and Aschkinass have previously shown that water-vapour has a considerable absorptive power in the ultra-red part of the spectrum and possesses a series of absorption bands at $11{\cdot}6\mu$, $12{\cdot}4\mu$, $13{\cdot}4\mu$, $14{\cdot}8\mu$, $15{\cdot}7\mu$, and $17{\cdot}5\mu$. Also in the region of still greater wave-lengths, where spectroscopic methods fail, water-vapour belongs to the strongly absorbing gases, since a layer of water-vapour 40 cm. thick at 100° C. and atmospheric pressure completely absorbs the residual radiation from rock-salt and sylvin, and the greater part from potassium bromide and iodide. The possibility is therefore that the absorption by water-vapour in the long-wave region is strongly selective, even as in that lying between 11μ and 18μ in the spectrum. On this ground Hollnagel tried to find whether water-vapour had considerable influence on the energy distribution in the residual radiation from rock-salt, but he obtained a negative result. The latter has since been explained as due to the fact that the vapour layer placed in the path of the beam was too small in comparison with that already present in the path. The author has renewed his experiments owing to the discovery of new groups of residual rays. These experiments are described in great detail, accompanied by diagrams and explanatory curves. The results obtained show that the residual radiation from rock-salt, sylvin, and potassium bromide, is made up of two neighbouring spectral regions, since the corresponding energy distribution curves exhibit two maxima. Hollnagel obtained quite similar curves with other light-sources and a varying number of reflecting surfaces, finding that the position of the maxima only varied a little with the source, and travelled slowly towards the long-wave region with increasing number of reflections. It is later established that this result does not depend alone on selective reflection, but also on the lengthening of the moist air path due to increasing number of reflections. The author then describes some new experiments with the same substances, giving numerous curves for different sources (dark body and Auer burner), varying lengths of path, and changes in amount of water-vapour present. A further set of experiments by the author and v. Wartenberg are described with a new series of residual rays from silver chloride, silver bromide, calomel, and lead chloride. In these cases, especially with silver and lead chlorides, the energy curves show certain minima in those parts of the spectrum where the presence of absorption bands for water-vapour are assumed. The experimental details are very full. Since the cause of several maxima is believed to be due to the selective absorption of water-vapour this absorption spectrum of water-vapour must occur when other experimental conditions prevail. Accordingly experiments with a special quartz lens arrangement have been carried out by the author and R. W. Wood, whereby the separation of the long-wave radiation is not caused by selective reflection. Tables of results and illustrative curves are given. Finally, the selective absorption of quartz receives detailed attention. The collected results are :—(1) The absorption by water-vapour in the atmosphere influences considerably the energy distribution of the residual radiation, the two-fold division by rock-salt, sylvin, and potassium bromide being thereby brought about. (2) The average wave-length of the residual radiation shows, on the contrary, only a slight dependence on the atmospheric water-vapour. (3) The average wave-lengths of the residual radiation from AgCl, $PbCl_2$, Hg_2Cl_2, and AgBr were measured by the author and v. Wartenberg, and found under the conditions employed to be 81·5μ, 91·0μ, 98·8μ, and 112·7μ. (4) In the energy-curves, especially those of AgCl and $PbCl_2$, peculiarities occur which in conjunction with the interference curves must be ascribed to absorption by water-vapour. These peculiarities also persist in the energy distribution of long-wave radiation isolated by a special quartz lens arrangement. (5) Water-vapour has strong absorption between 45μ and 120μ, this being especially intense at 50μ, 66μ, and 79μ. Relatively high permeability occurs, on the other hand, at 47μ, 54μ, 62μ, 75μ, 91μ, and 115μ. (6) Quartz, in the spectral region investigated, viz., between 53μ and 113μ, shows pronounced dichroism in the sense that the radiation is more strongly absorbed when the electric vector vibrates perpendicular to the axis than when it is parallel. H. H. Ho.

1448. *Combustion of Gaseous Mixtures and Retardation on Ignition.* **Taffanel** and **Le Floch.** (Comptes Rendus, 156. pp. 1544–1546, May 19, 1913.)—The course followed by the combustion of mixtures of methane and air is studied by introducing small quantities of the mixtures into an evacuated silica flask which has a content of 300 c.cm. and is heated electrically. By means of a special cock, which opens and closes automatically, this introduction is effected in less than 0·03 second, and 0·05–0·12 second after the shutting of the cock the mean temperature of the gas differs from that of the wall of the flask by only about 10 deg. A registering manometer records photographically the variation of pressure in the flask as a function of the time. The ignition of mixtures of methane and air, which is rendered evident by the flash and also by a sharp rise in pressure, occurs only after the lapse of a certain time varying with the temperature of the flask and with the composition of the gaseous mixture. This retardation is observed also with moist mixtures of the gases so that the usual explanation—that explosive combustion requires the presence of a certain quantity of water—falls to the ground. It seems rather that the velocity of reaction of these gaseous mixtures increases with the temperature less rapidly than with mixtures which exhibit no such retardation. T. H. P.

1449. *The Trouton Quotient and the Molecular Heat of Evaporation of Pure Substances Boiling at High Temperatures.* **de Forcrand.** (Comptes Rendus, 156. pp. 1648–1651, June 2, 1913.)—The author has recently (Ibid. pp. 1439–1443, May 13, 1913) pointed out that Trouton's law can now be regarded only as an approximate relation applicable at temperatures lying between 250° and 900° absolute. Making use of values of the heats of evaporation given by various investigators, he has now applied the modified form of Trouton's law, $L/T = 10{\cdot}1 \log T - 1{\cdot}5 - 0{\cdot}009T + 0{\cdot}0000026T^2$, to the metals, Hg, Cd, Zn, Bi, Pb, Ag, Sn, and Cu, the boiling-points of which vary from 630° to 2583°. The Trouton constant increases from 22·185 for Hg to 27·063 for Cu, and the values of the latent heat, L, calculated from the above equation are in good agreement with those determined experimentally. For carbon, with an estimated boiling-point of 3800°, the heat of vaporisation is calculated to be 144·4 cals. T. H. P.

1450. *The Trouton Quotient and the Heat of Vaporisation of Pure Substances Boiling at Low Temperatures. Data for Helium.* **de Forcrand.** (Comptes Rendus, 156. pp. 1809–1813, June 16, 1913.)—The modified form of Trouton's equation [see preceding Abstract] is applied to substances of low boiling-points. With chlorine, radium emanation, oxygen, nitrogen, hydrogen, and helium the values of L/T diminish as the boiling-point falls, and vanish at zero absolute. The author's formula and that of Nernst show good agreement. In the case of helium it is shown how, with the aid of Clapeyron's formula, the heats of vaporisation can be calculated from the vapour pressures and the corresponding temperatures. T. H. P.

1451. *Thermoelectric Methods in Calorimetry.* **W. P. White.** (Washington Acad. Sci., Journ. 3. pp. 319–321, June 4, 1913.)—The paper deals with the securing of certainty and high precision in calorimetric measurements by means of the thermo-element. Various new modified thermoelectric methods are referred to. The essential feature of the methods is to use, around the "cold junction" of the thermo-element, in place of an ice bath, a body at nearly the same temperature as the calorimeter. The smallness of the electrical quantity to be measured then gives to the temperature measurement extraordinary precision combined with great ease. Thus these methods while specially advantageous for precision in determining very small heat quantities, are in nearly all cases among the best in convenience and certainty. J. J. S.

1452. *Value of the Constant in Stefan's Formula.* **C. Féry** and **M. Drecq.** (Journ. de Physique, 3. Ser. 5. pp. 380–384, May, 1913.)—Two previous sets of measurement of the energy radiated from a hot black body to a colder conical black body acting as a receiver had given values of σ in Stefan's formula, $E = \sigma T^4$, in very close accordance as regards the experiments in the same series, but with a difference of 3·1 per cent. between the means of the two series. The authors attributed this difference to a possible error of 0·8 per cent. in determining the furnace temperature, as any such error would be quadrupled in the value obtained for σ [Abstract No. 905 (1911)]. The respective means were 6·3 and 6·5, while Bauer and Moulin [Abstract No. 1285 (1910)] had obtained the value $\sigma = 5{\cdot}3 \times 10^{-12}$ (watt. cm.$^{-2}$ degree^{-4}). They now employ a plane receiver, the objections they had previously shown to apply to this form being eliminated by measuring the energy dissipated instead of the energy received by the bolometer through the variation in its resistance. The measurements were in close accordance with each other and gave a value of 6·2 for σ. The authors note that in these latest measurements Lambert's law was assumed to hold with exactness for platinum black. They are of opinion that the mean of the means obtained in the three series, $\sigma = 6{\cdot}33$, is the most probable value, with a probable error of not more than 0·5 per cent., or $\sigma = 6{\cdot}33 \pm 0{\cdot}03$. G. W. de T.

1453. *Deduction of Planck's Law of the Distribution of Energy from the Agglomeration Hypothesis.* **C. Benedicks.** (Comptes Rendus, 156. pp. 1526–1529, May 19, 1913.)—The author states that it is natural to enquire whether molecular variations are able to explain the differences in the atomic heats of solids [see Abstract No. 1699 (1908)]. He proposes to show briefly that the hypothesis of the progressive agglomeration of solid atoms [agglomeration being a term employed in lieu of polymerisation, association, etc., to indicate that it is unnecessary to invoke chemical forces] whereby at absolute zero there remains no further thermal movement, may lead to Planck's law which is the basis of the modern theory of atomic heat (by Einstein and others). By considering a molecule of a crystallised solid, its energy W is found to increase with the temperature T in a linear manner, viz., $W = 3RT$, if all its atoms are free at $T = 0$, but if the atoms are agglomerated, then W will increase much more slowly, since the absorption of thermal energy is proportional to the amount of agglomeration to be destroyed. The energy-temperature curve then becomes: $W = 3RT - W_0 + F(T)$, where F(T) is a function representing the energy of agglomeration and W_0 the energy at $T = 0$. There are two factors which should have a preponderating influence upon F(T), namely: cohesion, which in crystals has a vectorial nature, and thermal motion whose influence will be to disperse the agglomerated atoms. This problem is closely linked with the case calculated by Langevin, of a paramagnetic gas in a directed magnetic field. Assuming Langevin's result, a formula is obtained identical with the law of Planck. The author then makes the plausible assumption that F(T), which measures the agglomeration, is directly proportional to the cohesion H and inversely to the atomic weight A. The greater the attraction and the smaller the mass, the less the probability that thermal agitation will cause dis-agglomeration. A formula is then obtained again identical with Planck's law, and without recourse to the theory of quanta. The author has put forward these considerations to show that the hypothesis of quanta is not the only one leading to Planck's law, and opines that in order for the hypothesis of quanta, which is contrary to mechanical principles, to continue to hold its ground, it seems absolutely necessary to demonstrate either that the existence of agglomeration is fictitious, or that if possible it must not obey Langevin's formula.

H. H. Ho.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

1454. *Unipolar Induction.* **E. H. Kennard.** (Phys. Rev. 1. Ser. 2. pp. 355–359, May, 1913.)—S. J. Barnett concludes that neither the author's experiments nor his own can settle the question as to motion of the force lines. The author objects to his arguments as assuming that the electric density ∝ div *f* (total intensity) in all cases, which is not the case, and also as treating the ether as equivalent to a material dielectric, which is inadmissible; in electrostatics ether and matter are diametrically opposed, for an outward displacement in matter (across a closed surface) leaves behind it in the matter a negative (free) charge, whereas an outward displacement in free ether leaves behind it a positive charge; and this difference is essential. The author concludes that both Barnett's experiments and his own do invalidate at least the simplest and most natural form of the old moving-line theory. [See Abstracts 1859 (1912), and 209, 210, 1179 (1913).] A. D.

1455. *Circular Plate Condenser.* **H. Thirring.** (Akad. Wiss. Wien, Ber. 121. 2a. pp. 2133–2141, Dec., 1912.)—A mathematical investigation of the charge which is induced on a circular plate condenser by an electric double layer. J. J. S.

1456. *Surface Charges on Conductors in a Vacuum.* **E. Gehrcke** and **R. Seeliger.** (Deutsch. Phys. Gesell., Verh. 15. 11. pp. 438–450, June 15, 1913. Communication from the Physikal-Techn. Reichsanstalt.)—It is well known that when conductors *in vacuo* are subjected to ultra-violet or kathode-ray radiation a double electrical layer forms. These surface charges on metals are altogether different from the polarisation layers of Volta-effects, as is proved by the difference in their orders of magnitude. Experimental arrangements and methods are described in detail. As the result of the observations the following are the most important conclusions arrived at:— By the action of the kathode-ray radiation on solid conductors, surface charges of several volts are built up, often after a few seconds. These gradually diminish with the time, but are still measurable after a day. These surface charges are positive after a short (a few minutes) radiation; with longer radiation they become negative. Surface charges can be dispersed (best in moist gases) by sufficiently intense kathode scattering. Metal surfaces so treated are immune against new radiation in a field-free space, *e.g.* a radiation with kathode rays of 240–800 volts for 1 hour did not produce a double layer of 1/10 volt. This method of kathode scattering is applicable also in gases containing fat and Hg vapours. Treatment with hot concentrated HNO_3 does not prevent the formation of a double layer on Pt. The double layer on Pt-foil is not dispersed by raising the temperature to a red or yellow glow when it is positive; on the other hand, negative double layers can be dispersed by feeble glowing. Dry air, hydrogen, and oxygen disperse the once-formed double layer, generally very much less quickly than does moist. Immunity against new radiation with kathode rays is not produced by dispersing the double layer by means of very moist gas. A. E. G.

1457. *Kinetics of Dielectrics: the Melting-point, Pyro- and Piezo-electricity.* **E. Schrödinger.** (Akad. Wiss. Wien, Ber. 121. 2a. pp. 1937–1972, Nov., 1912.)—The author begins by remarking that while van der Waals' theory explains the difference between the gaseous and liquid state, it no longer holds for the transition from liquid to solid. The considerable volume-change from gas to liquid is easily understood from a mechanical standpoint, but the smaller change on crystallisation cannot have the same significance in view of opposite volume-changes as in the cases of ice and sulphur. He then comments on the unsatisfactory explanation of fusion as a mere loosening of the forces between the molecules. The solid state is particularly characterised by crystalline structure, since amorphous bodies have no definite melting-point or heat of fusion, the transition to the liquid state being continuous; the latter are more correctly regarded as highly viscous fluids. The author, after asking why this particular structure suddenly begins at a quite definite temperature, states that although thermodynamics supplies a general answer, atomistics has not yet responded. He therefore attempts a solution of the problem on atomistic lines, admitting it, however, to be inconclusive and with many defects, since equations of state are still lacking. Interesting conclusions are drawn from an observation made from Debye's work on a kinetic theory of insulators. Debye concluded that his theory of dielectrics was of no practical importance below the critical temperature, and opined that in the solid state the assumption of the free rotation of molecules is no longer tenable. The author then describes his modification of Debye's theory, and declares his belief in free rotating molecules, the idea of which in the case of magnetism has been attended with such brilliant success. He states that Debye's dielectrics are solid below the critical temperature, and that solid bodies owe the firm coherence of their parts to intense self-electrification, which directs parallel all molecular moments, similar to the case of a liquid in an electric field, thereby bringing about the structure exhibited by every true solid. On the above modification it is clear that the critical temperature given by the theory must be lower than the observed fusion temperature.

The true internal conditions of a solid are next reviewed, the possibility of three different properties in three directions at right angles noted, and suitable modifications of the theory suggested. This leads to the investigation of the dielectric behaviour of an elementary crystal. Three equations are then evolved, corresponding to a correct choice of co-ordinates, expressing the connection between field strength and electrification, while two others are necessitated by the fact that the electrification which occurs is parallel to the total electric field strength. The mathematical development then leads to the result that the functional dependence between spontaneous electrification and temperature for all dielectrics is the same as that between the saturated magnetisation and temperature of an iron magnet. The elementary crystal is found to behave as an anisotropic dielectric with three different dielectric constants in three directions at right angles, and theory suggests that special anomalies in the behaviour of dielectrics may appear just below the melting-point. While one of the three constants depends in a very complicated manner on the temperature, the remaining two are independent. In a quasi-isotropic crystalline body the elementary crystals must have every possible direction, so that their dielectric constants will be the arithmetic mean of the three possessed by the elementary crystal, and also dependent in a very complicated manner on the temperature. The special case of $\mu b > 1$ (where μ is defined by $E_t = \mu P_s/3$, E_t being the total field strength and P_s the dielectric polarisation) is then discussed. The nearer

μb is to unity the greater the self-electrification at a definite temperature; when $\mu b > 1$ no finite value of the electrification can be reached, while the critical temperature becomes infinite or takes a negative value. The latter is without meaning. No liquid dielectric, therefore, can have a value $\mu b > 1$. The author, however, believes the case $\mu b > 1$ to have an important physical significance. Should such a body exist it would naturally be unstable, and the polarisation would rapidly grow without a stable condition being attained, until the molecular union breaks down; electrons will then be ejected until μb becomes < 1. In this way a chemical reaction may receive interpretation as being an electrically unstable mixture changing into more stable molecular combinations. If the latter are not possible, then part of the evolved electrons must remain free as in the case of electrolytic dissociation, and perhaps the metallic state.

The piezo-electricity of an elementary crystal next receives attention from the standpoint of the fundamental equations. The author considers real crystals as built up of these crystal elements; he takes quartz and tourmaline as examples, since these have had their piezo- and pyro-electrical properties most thoroughly investigated. The dimensions of the piezo-electric phenomenon are then discussed, data being given for methyl, ethyl, and amyl alcohols, and ethyl ether. The author claims as a most important support to his theory that actually all piezo-electrical constants are of the order 10^4 e.s. units, and considers it to be the first time that a theory has given correct values for the dimensions of piezo-electrical effects, without any assumption as to the electrical moments of molecules, the number of quanta elements, etc. Pyro-electricity is then examined, this being most related to the question of spontaneous electrification. The author then gives a mathematical demonstration showing that the dimensions of pyro-electric constants are also correctly given, results affording additional support to his theory. Voigt's experiment of determining the permanent electrical moment of tourmaline when a rod is broken parallel to the axes is mentioned. The charges on the fracture planes being measured, a negative charge of about 33 c.g.s. per square unit was found on the place which is positively electrified on heating. This result is qualitatively in unison with the theory.

The last point for investigation is the change of melting-point by pressure. A deformed crystal is assumed to have its critical temperature altered, and a comparison is made between the latter and the experimental fact of the change of melting-point by pressure. In the case of water, the author holds that the product μb must lie near to unity, thus accounting for the high dissociating power of water compared with other liquids. In conclusion, the author remarks that a profound orientation of the molecular axes occurs below the critical temperature, bringing into action quasi-electric forces if the electrons have their configuration changed, and thereby accounting for the incomplete character of Debye's theory. His own modification involves no complicated reasoning, and has the advantage of being in accord with experience. H. H. Ho.

1458. *The Ohm, the Ampere, and the Volt: A Memory of Fifty Years,* 1862–1912. **R. T. Glazebrook.** (Inst. Elect. Engin., Journ. 50. pp. 560–589; Discussion, pp. 589–592, June, 1913. Fourth Kelvin Lecture. Electrician, 70. pp. 1014–1017, March 7, 1913.)

1459. *Relativity Theory for Moving Bodies.* **R. Grammel.** (Ann. d. Physik, 41. 3. pp. 570–580, June 24, 1913.)—The electro-dynamics of moving bodies on the relativity principle. E. H. B.

1460. *Trajectory of Luminous Rays in the Gravitational Field.* **B. Caldonazzo.** (N. Cimento, 5. Ser. 6. pp. 267–300, April, 1913.)—Mathematical.

1461. *Electromagnetic Potential of a Moving Point Charge.* **M. Francesco.** (N. Cimento, 5. Ser. 6. pp. 255–266, April, 1913.)—Mathematical.

DISCHARGE AND OSCILLATIONS.

1462. *Motion of Electrons in Gases.* **J. S. Townsend** and **H. T. Tizard.** (Roy. Soc., Proc. Ser. A. 88. pp. 336–347, June 2, 1913.)—Methods are given of measuring, with the same apparatus, the two properties characteristic of the motion of electrons, viz. the abnormal lateral diffusion of a stream of ions moving in a uniform magnetic field, and the deflection of the stream by a small transverse magnetic force, with larger variations in the electric force and pressure than were admissible in the separate measurements of the two phenomena described in earlier papers. [See Abstracts Nos. 1403 (1912) and 215 (1913).] The results showed that the electrons adhere to the water molecules in the case of damp air, and that, when the electric force is small, the velocity of agitation of the charged particles is normal. For large forces the effect of the water-vapour disappears, and the electrons move freely with a kinetic energy of agitation exceeding that of the surrounding molecules by a factor k which could better be determined by the apparatus here described, in the case of large increases in the velocity of agitation, than by the method previously employed. The electric force Z being measured in volts per cm. and the pressure p in mm., the experiments show that when $Z/p > 0{\cdot}2$ the ions in dry air are in the electronic state, so that the value of e/m may be taken as $5{\cdot}3 \times 10^{17}$. The value of e/m for a molecule of air being 10^{13}, the masses are in the proportion $5{\cdot}3 \times 10^{4} : 1$, so that the velocity of agitation of an electron in thermal equilibrium with air is 230 times the velocity of agitation of a molecule of air, or 10^7 cm. per sec. The actual velocities of agitation when electric forces are acting exceed this value by the factor $\sqrt{k}$. In order that the ordinary formulæ derived from the kinetic theory of gases should apply to the motion of the electrons it is necessary that the velocity W in the direction of the electric force Z should be considerably less than the quantity $\sqrt{k} \times 10^7$. G. W. de T.

1463. *Abnormal Kinetic Energy of an Ion in a Gas.* **F. B. Pidduck.** (Roy. Soc., Proc. Ser. A. 88. pp. 296–302, May 8, 1913.)—Townsend [Abstract No. 518 (1909)] showed that when a stream of ions is moving in an electric field the extent to which it spreads out as it advances depends on the dryness of the gas as well as on the electric force, indicating that the rate of diffusion in dry air is abnormally great in comparison with the velocity under an electric force. It was suggested that this could be explained on the supposition that the ions were not in "thermal equilibrium" with the molecules of the gas, but that their mean kinetic energy exceeded that of an equal number of gas molecules in the ratio k to unity, where k depends on the pressure and the electric force. Both Townsend and Haselfoot have shown that k is, at any rate approximately, a function of X/p only, where X is the electric force and p the pressure of the gas. It seemed desirable to investigate the matter quantitatively on the basis of the kinetic theory of gases, since we are here dealing with the validity or non-validity of the law of equipartition of energy. Using Maxwell's method of treatment it is shown that it is easy to obtain theoretical support for the assumption of abnormal kinetic energy; in fact, the values of k predicted by pure theory are considerably in excess of those actually observed. A. W.

1464. *Velocities of Photo-electrons.* **A. L. Hughes.** (Phil. Mag. 25. pp. 683–686, May, 1913.)—Investigations have shown [Abstract No. 1874 (1912), etc.] that metallic surfaces, when illuminated by ultra-violet light, emit electrons whose max. energy is a linear function of the frequency. Most of the photo-electrons emerge from the surface with velocities appreciably less than the maximum, on account of the loss of energy by collisions in their journey from the interior. If V is the potential required to stop the fastest electrons, and e the charge, then the experimental relation between the max. energy Ve and the frequency n is $Ve = h'n - V_0e$, where h' and V_0 are experimental constants. This is also the type of formula suggested by the quantum theory. If h be Planck's constant, then hn is the unit of energy associated with the frequency n, and it may be assumed to be the amount of energy acquired by the photo-electron. If V_0e represents the loss of energy in getting away from the parent molecule, then the theoretical relation would be $Ve = hn - V_0e$. The experimental values for h' are all less than Planck's h by amounts ranging from 10 to 25 %. In these experiments the max. velocities of photo-electrons emitted from the same side of the plate as the incident light were investigated. In experiments on thin Pt-films, however, Robinson has recently shown that the velocities of the emergent electrons are greater than those on the incident side, the difference in energy for an infinitely thin film corresponding to about 12 %. It may be surmised, therefore, that probably all the electrons are emitted originally from the molecules in the direction of the light and that subsequent scattering leads to emission in all directions. Putting in Robinson's correction for the case of Pt, the author shows that h' and h are in agreement, thus indicating that the application of the quantum theory to photo-electricity is quantitatively justified. Using the theory in the case of oxygen for which it is known that the critical wave-length to excite ionisation is λ1350, the author calculates that the value of V_0, or the ionising potential, is 9·2 volts, which is in good agreement with the value 9·0 volts found by Franck and Hertz. The author is investigating the ionising potential determined in this way for the same substance in different physical states. E. M.

1465. *Velocity of Electrons Liberated by Photoelectric Action.* **K. T. Compton.** (Phys. Rev. 1. Ser. 2. pp. 382–392, May, 1913.)—The relation between the velocities of the electrons liberated by the action of light on metals and the wave-length of the incident light has been widely studied, but with quite conflicting results. The superposition, on the effect under investigation, of secondary effects due to reflected light and reflected electrons, to variable contact p.d. between the emitting and receiving electrodes, to electrostatic leakage, to impurity of the spectrum, etc., have proved difficulties. O. W. Richardson and the author appear, however, to have eliminated very largely these sources of error and have obtained consistent results which support the view that the velocity of the liberated electrons is a linear function of the frequency of the incident light. A. L. Hughes arrived at similar conclusions by an independent method. These results agree that the relation between the velocity and the frequency may be accurately represented by an equation of the form $V = kn - W_0$, where V is the initial kinetic energy of the liberated electrons, expressed in equivalent volts, k and W_0 are constants, and n is the frequency of the incident light. This type of equation was first developed by Einstein on the unitary theory of light and recently by O. W. Richardson by thermodynamic and statistical methods. J. Kunz, on the other hand, assuming that light consists of discrete vibrating Faraday tubes has obtained a formula showing that the energy of the liberated electrons varies as the square of the frequency. D. W. Cornelius has recently published results, which claim to support Kunz's theory and to discredit the Einstein-Richardson formula. The present paper points out certain errors and inconsistencies in the results obtained by Cornelius, and endeavours to prove that when these are corrected the support of Kunz's theory is much less convincing; in fact, Cornelius' results seem rather to lend support to the rival theory. A. E. G.

1466. *Photoelectric Phenomenon Exhibited by Liquid Sulphur Dioxide.* **J. Carvallo.** (Comptes Rendus, 156. pp. 1882–1884, June 23, 1913.)—The experiments previously described [see Abstract No. 167 (1911)] were carried out in the dark. It is now found that the phenomenon then observed is sensitive to the influence of light, alternate extinctions and renewals of the light resulting in alternate and immediate increases and decreases in the current. The extents of these changes depend on the constitution and intensity of the source of light; they increase with the intensity of the current passing, while they become smaller and tend towards zero if the current is allowed to flow sufficiently long in the dark. After the sixth extinction, the current-time curve passed through a maximum of about 60×10^{-6} amp. Both the "positive" or extinction effect and the "negative" or illumination effect have their origin in the body of the liquid and not at the surface of the electrodes, and are produced simultaneously by the same ultra-violet radiations (absorbable by quinine) capable of traversing the glass walls of the vessel containing the liquid SO_2. The positive effect results from the reaction, $3SO_2 = S + 2SO_3$, which is brought about under the action of light; the products of this reaction remain in solution in the sulphur dioxide and increase the conductivity of the liquid, but in the dark the current removes them from the field by a mechanism analogous to the electrical purification previously mentioned (*loc. cit.*). The negative effect appears to be of a purely physical nature, its existence being connected not only with the presence of impurities produced by the action of light, but also with the prolonged passage of a continuous current. T. H. P.

1467. *Emission of Electrons from Tungsten at High Temperatures. An Experimental Proof that the Electric Current in Metals is carried by Electrons.* **O. W. Richardson.** (Science, 38. pp. 57–61, July 11, 1913. Phil. Mag. 26. pp. 345–350, Aug., 1913. Phys. Zeitschr. 14. pp. 793–796, Sept. 1, 1913.)—The view appears to have become rather prevalent that the emission of electrons from hot bodies is invariably a secondary effect arising in some way from traces of chemical action. The experiments with tungsten filaments here described shows that this view is a mistaken one. The tests were made with tungsten lamps carrying a vertical filament of ductile tungsten which passes axially down a concentric cylindrical electrode of Cu gauze or foil. The filaments are welded electrically in a hydrogen atmosphere to stout metal leads. These in turn are silver-soldered to Pt-wires sealed into the glass container. The lead to the Cu electrode is sealed into the glass in the same way. The lamps are exhausted with a Gaede pump for several hours, during which they are maintained at a temperature of 550°–570° C., by means of a vacuum furnace. The exhaustion is then completed by means of liquid air and charcoal, the tungsten filament meanwhile being glowed out at over 2200° C., by means of an electric current. Most of the tests were made after the furnace had been opened up and the walls of the lamps allowed to cool off. They were always considerably above the temperature of the room on account of the heat radiated by the glowing filament. The tests carried out cover the following alternate hypotheses as to the possible mode of origin of the electronic emission :—(1) The emission is due to the evolution of gas by the filaments. It is found that the number of electrons emitted for each molecule of gas evolved is $> 5{\cdot}64 \times 10^6$ when mercury vapour is kept from the filament, which effectually disposes of this idea. (2) The emission is caused by chemical action or some other cause depending on impacts between the gas molecules and the filaments. If the gas is assumed to be hydrogen the ratio N_2/N_1 is $> 4{\cdot}47 \times 10^8$, while if the hydrogen atoms simply turned into a cloud of electrons with a total mass equal to that of the hydrogen the value of N_2/N_1 would be only $8{\cdot}68 \times 10^3$. Thus the emission of electrons has nothing to do with the impact of gas molecules under the conditions of these experiments. (3) The emission is the result of some process involving consumption of the tungsten. There is no known reason for believing that the loss of tungsten is due to anything more profound than evaporation. It is shown, moreover, that the mass of emitted electrons can, under favourable circumstances, exceed that of the tungsten. (4) The emission is due to the interaction of the tungsten with some unknown condensable vapour which does not affect the McLeod gauge. This is cut out by the fact that the thermionic emission is not affected when the liquid air and charcoal is cut off, and by the fact that very considerable changes in the amount and nature of the gases present have no effect on the emission. It thus follows that the emission of electrons from hot tungsten, which there is no reason for not regarding as exhibiting the phenomenon in a typical form, is not a chemical but a physical process. This conclusion does not exclude the possibility that, under other circumstances, electrons may be emitted from metals under the influence of various chemical reagents, but it does involve a denial of the hypothesis that this emission is invariably caused by processes involving changes of material composition. The experiments also show that the electrons are not created either out of the tungsten or out of the surrounding gas. It follows that they flow into the tungsten from outside points of the circuit. The experiments therefore furnish a direct proof of the electron theory of conduction in metals. A. E. G.

1468. *Normal Photo-effect with Potassium Amalgams of Different Concentrations.* **R. Pohl** and **P. Pringsheim.** (Deutsch. Phys. Gesell., Verh. 15. 11. pp. 431–437, June 15, 1913.)—It has been known for some time that K-Hg amalgams with less than 2·5 atoms per cent. of K possess a normal photo-effect which has been ascribed to the potassium alone. Previous experiments, however, show that the number of electrons emitted from K-amalgams is disproportionately large for the percentage of K present. The experiments now described show that the normal photoelectric emission of electrons from K-Hg amalgams between 2×10^{-4} and 2·3 atoms per cent. of K is of the order of magnitude of the effect obtained with pure K. It begins with 2·3 atoms per cent. somewhere in the blue, and with diminishing concentration the wave-length limit is gradually displaced towards the shorter wave-lengths. The emission at some distance from the long-wave limit remains constant within about 30 % for concentrations varying $1 : 10^4$. The theoretical aspect of the question is briefly discussed. A. E. G.

1469. *Goldstein's Invisible Kathode Rays.* **A. Wehnelt.** (Ann. d. Physik, 41. 4. pp. 739–750, July 17, 1913.)—From kathodes which fill the section of a cylindrical vacuum-tube come off at low pressures two kinds of kathode rays [see Abstract No. 1923 (1901)]. Of these, one is a central, very slightly divergent bundle, from a few sq. mm. at the centre of the kathode, and is usually fairly visible along the length of the tube. The other rays come from the whole surface of the kathode, and are the more divergent the nearer they are to the glass walls. They follow the level surfaces of the kathode and bend towards the glass walls. These rays consist principally of positive particles which have travelled up to the kathode and then lost electrons, just like the central bundle. Their invisibility is due to the comparative sparseness of the particles. The velocities are less the nearer the point of origination is to the periphery of the kathode. Ultra-violet rays have only a very feeble influence, if any, on the production of these rays: the author withdraws an opinion to the contrary [see Abstract No. 1102 (1901)]. A. D.

1470. *Secondary Canal Rays.* **H. Baerwald.** (Ann. d. Physik, 41. 8. pp. 643–669, June 24, 1913.)—The author has previously shown that Lenard's method may be employed to estimate the velocity of electrons emitted under the stimulus of electric light, also for the investigation of secondary canal rays [see Abstract No. 220 (1913)]. Using a new arrangement of apparatus, the following points have now been investigated:—(i) The dependence of the quantity of secondary radiation on the strength of the retarding field, using a certain material and primary radiation of definite kind and constant velocity. (ii) Variation of the velocity of the primary radiation. (iii) Variation of the gas contained in the discharge space. (iv) Variation of the material receiving the primary radiation. The quantity of the secondary radiation is proportional to the intensity of the primary radiation, but the velocity of the secondary electrons is independent of the intensity of the primary radiation. The higher velocity of a primary radiation particle corresponds to a higher velocity of the secondary electron emitted. With both hydrogen and air canal rays the following materials were dealt with: Al, Fe, Cu, Zn, Ag, Pt, Au, Pb; and with hydrogen canal rays alone: C, Mg, S, Ca, Tl, Bi, U, CuO. It was found that the nature of the substance is without effect on the quantity and velocity of the secondary radiation. A noteworthy point is that 95 % of all secondary-ray particles are slower than 10 volts, even when the highest discharge potentials are used. Lenard has obtained similar results. [See also Abstract No. 905 (1912).] A. W.

1471. *Magnetic Separation of Ions emitted by a Spark in Rarefied Gas.* **A. Righi.** (Le Radium, 10. pp. 134–136, April, 1913. Abstract of paper read before the Acad. Roy. des Sciences de Bologne, March 9, 1913.) Phys. Zeitschr. 14. pp. 540–543, June 15, 1913.—The object is to obtain a new proof of the existence of charged particles emitted by the spark. The method employed is to deviate the ions by a magnetic field and catch the charges by suitably placed electrodes. A diagram of the tube used is given. Results obtained show that with an air pressure of 0·04 mm. the current at first increases with the magnetic field, but, after reaching a clearly defined maximum at about 1100 units field, it rapidly decreases as the magnetic field is further increased. This is no doubt due, in part, to the direct influence of the field on the spark. This secondary influence is more marked at lower pressures. Thus, the max. current is observed with a field of 260 units when the pressure is 0·02 mm. Independent of these secondary circumstances, it has been proved that the current shows a max. intensity for a given magnetic field at a given pressure analogous to that which has been observed in the mechanical effects of particles emitted by the spark; thus, with a field of 1100 units there is at first an increase of current as the pressure is lowered, due to a decrease in the number of collisions, and a final rapid diminution for pressures less than 0·01 mm., which may be explained by the action of the magnetic field on the spark. By using a large induction coil it is possible to obtain currents sufficiently large to be measured by a galvanometer. A. E. G.

1472. *Scattering of Canal Rays.* **J. Stark** and **H. Kirschbaum.** (Phys. Zeitschr. 14. pp. 433–439, May 15, 1913.)—When canal rays encounter gaseous molecules they lose some of their velocity in the direction of the electric field. The Doppler-effect observed in the spectrum is thus diminished. The authors investigate this loss of speed in various gases and vapours ($HgCl_2$, Ar, O, He) and its dependence on the original speed. Oxygen canal-rays in oxygen show less of a Doppler-effect than in helium. In the latter gas certain irregularities appear in the spectrum which indicate various speeds. The spectrum of $AlCl_3$ vapour shows two distinct maxima of "motion intensity" adjoining the line 3961·7. The first corresponds to univalent Al; the second, which is greater and more distinct, corresponds to bivalent Al. The scattering converts bivalent into univalent ions and reduces their speed. Hg canal rays are greatly retarded in a $HgCl_2$ atmosphere as compared with a He atmosphere, and the maximum of motion intensity is closer to the original line. E. E. F.

1473. *Generation of Light by Nitrogen and Oxygen Canal Rays.* **L. Vegard.** (Ann. d. Physik, 41. 3. pp. 625–642, June 24, 1913.)—The author has previously shown [see Abstract No. 118 (1913)] that the "rest" and "moving" intensity for hydrogen canal rays vary in a quite different manner when the velocity of the rays or the gas pressure in the radiation space is altered. The experimental arrangements for the present study of canal rays in nitrogen and oxygen are essentially similar to those employed in that research. The displacement effects found for nitrogen and oxygen are much smaller than that found for hydrogen. This smaller value of the displacement is due to the different behaviour of the self-illumination of the rays. The intensity of self-illumination for hydrogen diminishes with increasing velocity, while for nitrogen and oxygen the intensity increases with increase of tension. For nitrogen and oxygen the max. velocity found from the Doppler-effect is approximately proportional to the square root of the tension, and the results obtained by optical methods are in good agreement with those obtained by W. Wien by deflection methods. For hydrogen, on the other hand, it is found that smaller velocities are obtained by the optical than by the electromagnetic method. This exceptional behaviour of hydrogen is explained by the law of self-illumination. A short discussion as to the probability of comet's tails being produced by positive rays is appended. A. E. G.

1474. *Reflection of Hydrogen Canal Rays.* **E. Wagner.** (Ann. d. Physik, 41. 2. pp. 209–230, June 3, 1913.)—J. J. Thomson [Abstract No. 1890 (1907)] and C. Füchtbauer have proved the reflection of canal rays by measuring the positive charge given up by the reflected rays, while B. Saxen [Abstract No. 1249 (1912)] has made calorimetric measurements of the same. Hermann, Kinoshita, Stark and Steubing have investigated the problem by means of the Doppler-effect. It is extremely difficult to avoid the reflection of the primary Doppler light from the glass walls and clean metallic surfaces; this objection, however, cannot be raised against the present experimental arrangements. A comparison is made of reflected canal rays by means of the Doppler-effect, transparent (glass) and opaque substances (aluminium and gold) being used as the reflectors. Aluminium and glass both exhibit the power of diffuse reflection towards hydrogen canal rays in a marked degree, gold does not reflect so well. A. E. G.

1475. *Influence of the Space Charge on the Anode-fall.* **R. Reiger.** (Deutsch. Phys. Gesell., Verh. 15. 10. pp. 397–401, May 30, 1913.)—C. A. Mebius and G. C. Schmidt [see Abstract No. 859 (1906)] have determined the kathode- and anode-fall of branch currents for different parts of the discharge. They found that for all parts of the discharge the kathode-fall for the same current is greater than the anode-fall, only in the dark space the reverse takes place. The explanation of this high anode-fall appears to be that the positive space charge causes delay in the escape of positive or entry of negative ions. The object of the experiments is to prove this assumption. Details of experimental arrangements are given. A comparison of the scattering of positive and negative charges in the dark space toward the anode shows that here, as in the kathode dark space, the anode-fall of a branch current is essentially greater than the kathode-fall, the difference being so much the greater the higher the pressure. With increasing length of sound the difference becomes smaller. The results are in accord with the assumption that the anode-fall is influenced by the space charge in its neighbourhood, being increased by positive and diminished by negative charges. A. E. G.

1476. *Influence of Space Charge on Striations and Striation Formation.* **R. Reiger.** (Deutsch. Phys. Gesell., Verh. 15. 11. pp. 428–430, June 15, 1913.)—Gehlhoff has published a series of observations on the formation of striations [see Abstract No. 488 (1913)] in which he mentions that the formation of striations always takes place in the Faraday dark space. J. J. Thomson has shown that a strong negative charge is present at the top of the striations, and expressed the opinion that the accumulation of negative electricity at the top of the striations is the most important factor in the generation of striations. As the result of the present experiments, it is found that striation formation occurs in that part of the discharge in which a space charge is present, *e.g.* in the Faraday dark space and at the sounds. The introduction of a sound into a striated discharge causes a displacement of the striations, especially in that part between the sound and the anode. By moving the position of the sound it is found that it favours the formation of striations when at the top of the striations. A. E. G.

1477. *Brush Discharge in Chlorine and the Connection between the Brush Discharge and Velocity of Ions.* **K. Przibram.** (Akad. Wiss. Wien, Ber. 121. 2a. pp. 2163–2168, Dec., 1912.)—Illustrations are given of the appearance of the brush discharge at anode and kathode in chlorine. The results lend support to a relationship previously noted, viz. that the positive brush is so much the greater and the difference in form of the two brushes is so much the more marked, the greater the ratio of the velocities v_- / v_+ in the gas concerned. According to the photographs obtained, the following list gives in descending order the ratio of the extension of the positive to that of the negative brush discharge: Ar, He, Air, O_2, H_2, N_2, CO_2, C_2H_2, Cl_2, the ratio v_- / v_+ for the same gases being Ar (1·27 to 151), He (1·24 to 100), N_2 (1·45 to 95), Air (1·87), O_2 (1·32), H_2 (1·19), CO_2 (1·0), C_2H_2 (0·98), Cl_2 ($<$ 1). It

appears to be established that in the inert gases Ar and He, in which there is the smallest electronic affinity, the positive brush exceeds the negative most in extension and branching. An explanation of the observations is offered.
A. E. G.

1478. *Heating Effect of an Electric Current through a Gas.* **A. Chassy.** (Journ. de Physique, 3. Ser. 5. pp. 396–399, May, 1913.)—By an examination of the heat disengaged by currents passing through hydrogen at pressures from atmospheric down to about 1 mm. of mercury the proportionality is established between the heat and the *first power* of the current. [See Abstract No. 226 (1913).]
E. H. B.

1479. *Movement of Luminous Centres in Electric Discharges.* **A. Perot.** (Comptes Rendus, 156. pp. 1679–1681, June 2, 1913.)—Movements of luminous centres in tubes containing hydrogen excited by a continuous current have been previously described [see Abstracts Nos. 854, 855 (1913)]. Experiments are now undertaken to compare the velocity of centres in helium and hydrogen: sodium and lithium are also employed for this purpose. In a tube containing a mixture of helium and hydrogen it is found that the velocities of the rays D_3 of helium and C of hydrogen are relatively small, being 500 m. per sec. at the maximum. Under the same conditions of pressure and current the velocity of hydrogen is the same, whether helium is present or not. The velocity of C is to the velocity of D_3 under the same conditions of pressure and current as 1 : 2·3. This ratio is very close to the ratio 1 : 2 of the molecular weights of hydrogen and helium. The comparison between sodium and lithium is made in air at atmospheric pressure, using a continuous discharge giving a flame about 15 mm. long. It is found that under these conditions the luminous centres move, as in the tube, from the kathode towards the anode. The velocities of these are high, being 400 m. for the red lithium ray in a flame produced by a current of 66 milliamps., and the ratio of the velocity of the red lithium ray to that of the D ray of sodium is found to be 1 : 3·1, that is, approximately the same as that of their molecular weights. From the fact that in those cases in which the influence of the wave-length is small, the velocities are nearly proportional to the atomic weight, it appears that the velocities communicated to the luminous centres are proportional to the molecular weights of the substance concerned at the beginning of their motion, and that the luminosity, really due to material centres, arises owing to collisions between the molecules and electrons in motion. The shock probably dissociates the molecule, in all cases producing centres of vibration and, in particular cases, emitting light.
A. E. G.

1480. *Spark Photographs at High Pressures.* **A. W. Porter** and **W. B. Haines.** (Röntgen Soc., Journ. 9. pp. 17–21; Discussion, pp. 21–23, April, 1913.)—The terminals of an induction coil are connected to two electrodes, one of which is placed on each side of a photographic plate in the dark, and the apparatus is arranged so that a single spark can be passed. The plate is afterwards developed in the usual way, the tracery which is visible in the actual spark appearing in fuller detail on the plate after development. The electrode in contact with the sensitive side of the plate may be the one attached either to the positive or to the negative terminal, and very different figures are obtained in the two cases. A spark chamber is specially constructed in which photographs can be taken at pressures ranging up to 16 atmos. As previously shown, the discharge in air at ordinary pressure when the negative is against the sensitive side gives characteristic fan-like expansions. As the pressure is increased there is a conspicuous change, and at a pressure of 2 atmos., instead of the fan-like expansions, a separation into two filaments takes place almost all the way along the main lines of the discharge. At 8 atmos. the change is still further accentuated; the filaments which fringe the main lines become shorter and shorter as the pressure increases. At this pressure it appears to be impossible to obtain the negative figures free from lines which are characteristic of the positive spark for the same gas; that is, a positive rebound takes place after the negative has occurred. At this stage the path of the return positive is quite different from the path of the negative. The positive streamers cut right across the negative path. At 4 atmos. pressure and upwards there is a tendency for them to begin to follow the main line of the adjacent negative spark. These fans, which are so prominent for air at ordinary pressures, are not obtained in any case unless there is free nitrogen present in the gas through which the discharge passes. In nitrogen, as the pressure is increased a little, the negative discharge will scarcely pass, and at about 5 atmos. there is practically no impression on the plate. The spark in oxygen passes specially easy. The figures, both positive and negative in the case of hydrogen, are always extremely small, amounting simply to a glow surrounding the terminal. In the case when the discharge is a positive one, as the pressure increases, the only marked effect is to make the discharge lines much finer. The difference between the various gases also is much less than in the case of negative so far as the general appearances are concerned, although there are considerable differences in detail. So far as the fan-like expansions are concerned everything confirms the original idea that they represent in some sense or another what may be called an explosion or disintegration. Plates illustrating the effects are given. In the *discussion*, **Porter** stated that although at low pressures the film has nothing sensibly to do with the effect, yet at high pressures the film becomes more important, but still it is the least important condition. The effect of a magnetic field upon these effects is discussed.

A. E. G.

1481. *Carriers of Negative Thermionic Current in a Vacuum.* **G. Owen** and **R. Halsall.** (Phil. Mag. 25. pp. 735–739, May, 1913.)—Metal wires contain considerable quantities of absorbed gases which are evolved at a high temperature, and some substances such as carbon and palladium disintegrate rapidly when raised to incandescence at a low pressure [see Abstract No. 858 (1913)]. The question therefore arises: Is the negative thermionic current conveyed solely by electrons or by an admixture of electrons and heavy gaseous or metallic ions? This point has been investigated in the case of Pt by one of the authors [see Abstract No. 2672 (1904)]. The results then obtained led to the conclusion that at temperatures below 1000° C. the negative thermionic current is carried solely by electrons, whilst at higher temperatures there appeared evidence of the presence in the discharge of about 5 % of heavy ions. The object of the present research is to ascertain the part played by these heavy ions. The metals studied are Pd, pure and commercial Pt, and Ir, and were in the form of wires about 0·4 mm. diam. The method of investigation is based on the retardation of the discharge by a transverse magnetic field. It is obvious that the magnetic field which just prevents an electron from reaching the electrode will be far too weak to produce an appreciable deflection of any charged particles of atomic dimensions that might be present. Thus by measuring the thermionic current to a distant electrode with and without the magnetic field, information can be obtained as to the relative proportions of electrons and heavy ions in the discharge. By this means it has been found that the carriers consist almost entirely of free electrons. If any of the discharge is carried by heavy ions, then the proportion of heavy ions to electrons is, for all temperatures, certainly less than 1 part in 2000, and probably less than 1 part in 10,000. The earlier results, in which 5 % of heavier ions was found, are discussed.

A. E. G.

1482. *Secondary Electrical Oscillations.* **K. F. Lindman.** (Ann. d. Physik, 40. 5. pp. 992–1022, April 29, 1918.)—The author investigates the radiation emitted by a resonator placed in the field of a Hertz oscillator. This radiation he calls "secondary." A thermo-element resonator, R_0, is placed perpendicular to the oscillator so that it is unaffected by the waves. The resonator under investigation, R_1, is then placed inclined at various angles to the line joining the oscillator and R_0, and the effect on R_0 is noted. The wave-length and damping of the secondary radiation are determined by resonance curves, the results being in accord with what is to be expected from theory.

T. P. B.

1483. *Diffraction of Electric Waves at Parallel Cylinders.* **F. Záviška.** (Ann. d. Physik, 40. 5. pp. 1023–1056, April 29, 1918.)—A purely mathematical paper. An exact theory of the diffraction of plane-polarised electric waves at parallel cylinders (conducting or dielectric) is given, no assumption being made as to the distance between the cylinders, so that the effect of one cylinder on another is taken into consideration. The direction of propagation of the waves is at first considered to be perpendicular to the plane containing the cylinders, and two cases are considered, viz. (1) when the electric field is perpendicular to the length of the cylinders, and (2) when it is parallel to the cylinders. Then the diffraction at two cylinders is considered when the direction of propagation of the waves is parallel to the plane containing the two cylinders, and the theory is shown to throw some light on certain experimental results of Grossman [see Abstract No. 720 (1910).]

T. P. B.

1484. *Velocity of Electric Waves along Wires enclosed in Metal Casing.* **J. Wallot** and **K. Schäfer.** (Ann. d. Physik, 41. 2. pp. 230–246, June 8, 1918.)—Experiments were made on the velocity of electric waves along two wires passing axially through two metal cylinders, which were kept in electrical contact by wires. The capacity and self-induction per cm. were determined by bringing the wire system into resonance with the oscillation circuit by a sliding bridge when the metal tubes were not present and when they were placed (1) at a potential loop, (2) at a potential node. It was shown in an earlier paper [see Abstract No. 200 (1912)] that the capacity per cm. is in accord with that calculated from theory, but that the self-induction is greater than theory requires, the result being that the velocity is found to be much less than that of light. These results are confirmed. The more carefully, however, the metal tubes are connected with metal sheeting the less does the experimental result vary from the theoretical, which indicates that it is difficult to keep the casings at zero potential as theory requires. The authors conclude that it is only with the greatest precautions that dielectric constants can be determined by placing substances in such cylinders surrounding wires.

T. P. B.

1485. *Waves in Coupled Oscillation Circuits.* **E. Dibbern.** (Ann. d. Physik, 40. 5. pp. 935–959, April 29, 1913. Extract from Dissertation, Kiel.)—The author investigates the waves in two coupled electric oscillation circuits by means of a pendulum interrupter. The period of oscillation is about 1×10^{-4} sec. The coupling is close, amounting to about 0·5. The theoretical potential curve of the two circuits is calculated and compared with the experimental curve, both when the circuits are in resonance and when they are out of tune. In addition to an air core in the primary self-induction, cores of iron filings in paraffin wax, of iron wire, and of solid iron are used. The theoretical and experimental results for the air and the iron-filings cores are in good agreement, showing that the self-inductance in the latter case can be regarded as constant and be determined with accuracy. The results with the wire core are fairly good. Only the experimental curves are given in the case of the solid core. T. P. B.

1486. *Energy of Short-wave Electric Transmitters.* **G. Leimbach.** (Phys. Zeitschr. 14. pp. 478–485, June 1, 1913.)—An investigation concerning the max. energy which can be imparted to Hertzian oscillators emitting waves of the order of 2 m. The energy may be increased by increasing the capacity, the potential, or the rate of sparking. As regards capacity, Hertzian transmitters with symmetrical antennæ are specially useful for short wave-lengths. The capacity of the antennæ determines the amount of energy radiated. Capacities in parallel with the spark-gap, and spark-gaps of great capacity are a useless waste of energy. The increase of the p.d., by subdivision of the spark-gap or compression of the gas, is more effective than an increase of the capacity. The rate of sparking can be increased to 10^4 per sec. Since several transmitters and receivers can be combined, Hertz oscillators may be advantageous in some conditions. E. E. F.

1487. *Theory of Impact Excitation of Electric Oscillations.* **H. Warfvinge.** (Jahrbuch d. drahtlosen Telegraphie, 7. pp. 126–152, June, 1913.)—The first part of the paper is a *résumé* of the history of impact excitation. Then follows a full theory of the method. Attention is paid, in particular, to the conditions at "critical coupling" and it is shown that at a certain "dissonance" between the primary and the secondary circuits and at a coupling which is practically the critical coupling, the two coupling-waves are theoretically exactly isochronous and equally damped, so that it is only possible to speak then of one oscillation. The required dissonance is in general small, but it increases with the difference between the log. decrements of the two circuits when uncoupled. An experimental part of the paper is to follow. T. P. B.

1488. *Refraction of Electric Waves by the Atmosphere.* **F. Kiebitz.** (Jahrbuch d. drahtlosen Telegraphie, 7. pp. 154–157, June, 1913.)—A calculation is made as to the refraction of electric waves by the atmosphere on the assumption that the density of the air falls off proportionally to the height. It is shown that this regular refraction greatly assists the waves in passing round the earth's surface, and that owing to the presence of water-vapour the effect is greatest over the sea. Irregularities in the density and moisture of the atmosphere cause irregular refraction, which is unfavourable to the regular propagation of the waves. These irregularities are most prevalent over land and during the day, and they have a greater effect on short waves than on long waves. The author therefore considers that, although other influences may be important in determining the range in wireless telegraphy, it is probable that refraction of the waves by the atmosphere may have a greater effect than is commonly assumed. T. P. B.

1489. *Propagation of "Wireless" Waves around the Earth's Surface.* **W. v. Rybczyński.** (Ann. d. Physik, 41. 1. pp. 191–208, May 22, 1913.)—A purely mathematical paper. It has reference to papers by March and Poincaré [see Abstract No. 919 (1912)]. The author shows that, in agreement with the theory of Nicholson and Poincaré, a damping factor affects the values of the potential function as given by March, which has considerable effect at great distances. In this damping factor there is a numerical factor which, according to the method of approximation employed, may have either the value 0·33 or 0·7, the result being that the damping is of quite different orders according as the numerical factor is given the first or second of these values. The theoretical results are compared with the experimental results of Austin, and there is satisfactory agreement if the numerical factor has the value 0·33. Finally the theory is extended to the case when the earth's surface is not assumed to be a perfect conductor. T. P. B.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

1490. *Electric Conductivity of Pure Ether.* **J. Carvallo.** (Comptes Rendus, 156. pp. 1609–1611, May 26, 1913.)—The author has previously shown how ether of an exceedingly high degree of purity may be obtained [Abstract No. 609 (1912)]. Determinations of the conductivity of the liquid, using an arrangement of apparatus due to Dunoyer, give the values $10·5 \times 10^{-16}$, $7·6 \times 10^{-16}$, practical units for the specific conductance in the two directions along the tube used. These values were found to be independent of the p.d. employed. A. W.

1491. *Resistance between Plates in Contact.* **F. Streintz and A. Wesely.** (Phys. Zeitschr. 14. pp. 489–497, June 1, 1913.)—A first investigation of the influence of pressure, temperature, current strength, state of surface, and duration of contact on the transition resistance of two brass blocks. The greatest stability of resistance was obtained with large surfaces of contact. The resistance due to air films cannot be got rid of by pressure. But an electrically perfect contact can be obtained by a film of bone oil pressed between the surfaces with about 1000 gm. per cm.^{2}. The oil is pressed out, taking the air with it. This justifies Kohlrausch's advice to oil the sliding contacts of rheostats. E. E. F.

1492. *Electric Conductivity of Certain Crystals.* **W. C. Röntgen** [partly in collaboration with **A. Joffé**]. (Ann. d. Physik, 41. 3. pp. 449–498, June 24, 1913.)—The present paper is the first of a series and deals with the experimental arrangements and a new determination of the Curie piezo-electric constant k for quartz. The mean value of this constant, here held to be the most accurate yet obtained, is $k = 6·94 \times 10^{-8}$ per dyne. The influence of radiations on the electric conductivity is to be dealt with in a later paper. E. H. B.

1493. *Measurements on Resistance of a Pyrites Crystal at Low Temperatures down to the Melting-point of Hydrogen.* **B. Beckman.** (Konink. Akad.

Wetensch. Amsterdam, Proc. 15. pp. 1384–1396, July 15, 1913. Communication No. 132*g* from the Phys. Lab., Leiden.)—The author has previously found the resistance to be a function of temperature in the case of a pyrites crystal from Gellivare, Malmberget, Sweden. The measurements embraced the temperature interval +100° C. to −193° C. and the formula $W = W_0 e^{at}$ was found to hold, where W_0 is the resistance at 0° C. and t is the centigrade temperature. The specific resistance at 0° C. in ohms per cm.-cube was $w_0 = 0{\cdot}00294$, while a was $3{\cdot}53 \times 10^{-3}$. The measurements were made with a Wheatstone bridge, other experimental details being given in the paper. The present paper contains a record of measurements down to −250° C.; another method was used to eliminate the possible errors of the contact resistances, in which the crystal was pressed between two copper electrodes through which the current was conveyed to it. Two other electrodes were firmly pressed against the longest side of the crystal, and the voltage between them measured with the compensation apparatus [see Abstract No. 1435 (1906)]. Tables of results are given; the values at low temperatures are found to be in better agreement with the formula than the earlier ones. Similar work by Reichenheim, Kœnigsberger, and Wesely [see Abstracts Nos. 1447 (1912), 673 (1913)], is referred to. H. H. Ho.

1494. *Piezo-electric and Pyro-electric Properties of Quartz at Low Temperatures down to that of Liquid Hydrogen.* **H. Kamerlingh Onnes** and **A. Beckman.** (Konink. Akad. Wetensch. Amsterdam, Proc. 15. pp. 1380–1388, July 15, 1913. Communication No. 132*f* from the Phys. Lab., Leiden.)—The authors have undertaken this investigation because of the fact that many properties of solid bodies are much simplified at very low temperatures, owing to the considerable decrease of the caloric motion. The piezo-electric modulus of quartz, perpendicular to the axis, has been measured, and also the pyro-electric phenomena which Friedel, Curie, and others, have examined at higher temperatures. The measurements were effected by the generation of electricity on a quartz plate, which was kept at low temperatures and compared with a similar plate at ordinary temperature. The generated charge was measured with a quadrant electrometer, while both plates were of the same kind as used in the ordinary Curie's instrument, *i.e.* they were cut parallel to the optical axis of the crystal, and with the broadest side perpendicular to one of the electrical axes. Experimental details are fully given, together with numerical results. The authors conclude that the cooling from 290° K. to 80° K. causes a decrease of 1·2 % in the piezo-electric modulus. A further cooling from 80° to 20° causes a much smaller change. The importance of this result is perhaps that the change in the piezo-electricity by cooling to low temperatures, seems to take place chiefly above the temperature of liquid air. The pyro-electric charge generated was found to be about proportional to the absolute temperature. H. H. Ho.

1495. *Capacity of Coils.* **W. Rietz.** (Ann. d. Physik, 41. 3. pp. 543–569, June 24, 1913. Extract from Dissertation, Zurich.)—A standard condenser is charged and then discharged through the coil in question and by means of a Helmholz pendulum interrupter the oscillation curve is obtained and the period of oscillation determined. The capacity of parts of the circuit other than the coil in question, and the self-induction of the coil are eliminated by using standard condensers of different capacities, and in this way the capacity of the coil under test is determined. The capacity of a single-layer unifilar coil is shown to be extremely small. Drude's formula for the capacity of such a coil gives correct results. In coils of several layers the capacity is greatest when the number of layers is two. The capacity, C, of a two-layer coil is shown to be given approximately by the simple formula, $C = elr/4d$, where e = dielectric constant of insulating material, l = length of coil, r = radius of the inner layer, d = difference in the radii of the two layers. The capacity is only approximately proportional to the length of the coil, but the proportionality improves with the number of layers. Of coils of several layers, having the same self-induction but differing in form, the one possessing the smallest capacity is that which has a large number of turns on a short length. T. P. B.

1496. *Dielectric Constant of Air at High Pressures.* **A. Occhialini** and **E. Bodareu.** (Accad. Lincei, Atti, 22. pp. 597–603, May 4, 1913.)—Continuing their investigation of this subject [Abstract No. 1048 (1913)] the authors have determined the dielectric constant (D) of air at pressures up to 384 atmos., with the following results :—

Pressure (atmos.).	D.	Pressures (atmos.).	D.
64	1·0357	196	1·1092
101	1·0567	217	1·1182
124	1·0684	255	1·1378
149	1·0839	298	1·1526
162	1·0908	384	1·1691
192	1·1058		

For all the results the ratio $(D-1)/(D+2) \,.\, 1/d \times 10^6$ is practically constant at 195, but the ratio $(D-1)/d \times 10^6$ shows considerable divergence as the density (d) increases. Calculated from the former ratio, the value of D relative to the atmosphere is 1·000585, which is almost identical with that obtained directly by Klemenčič, viz. 1·000586, and approximates to the value 1·000590 found by Boltzmann. W. H. Si.

1497. *Behaviour of Dielectrics after Electrical Excitation.* **E. Schreiber.** (Ann. d. Physik, 41. 4. pp. 767–811, July 17, 1913. Extract from Inaug. Dissertation, Göttingen.)—The dielectric under test, in the form of a cylindrical ring, is subjected to electric strain between two metal cylinders, the inner of which is charged while the outer is earthed. The dielectric does not touch the metal. It is then dropped into the space between two similar metal cylinders, the inner of which is connected to one pair of quadrants of an electrometer, while the outer is earthed, and the electrical behaviour of the dielectric is observed by means of the electrometer. The apparatus is fully described. The dielectrics tested are rosin, ebonite, shellac, sealing-wax, sulphur, and paraffin. It is found that freshly prepared ielectrics develop static charges which cannot be completely removed by a flame, X-rays, or a radio-active substance ; only after three or six months can the surface charge be completely removed. The after-effects of excitation are stronger and fall off more slowly the stronger the exciting field and the longer it has been applied. With a weak field the after-effect does not rise in proportion to the time of exposure. With a strong field the after-effect rises rapidly with the time of exposure, and then slowly approaches a maximum. Paraffin and sulphur both show an after-effect. The influence of the ions of the air on the rapidity with which the effect falls off is very small. An attempt is made to refer the difference in the behaviour of the dielectrics to the difference in their conductivities, and also to apply Wiechert's theory of the after-effects of elastic strain to the experimental results. T. P. B.

1498. *Thermo-electricity of Steels.* **W. Broniewski.** (Comptes Rendus, 156. pp. 1983–1985, June 30, 1913.)—Thermoelectric-temperature curves against copper have been determined in a series of pure steels, containing 0·07 % to 1·12 % carbon, and a sample of electrolytic iron. The latter showed A_2 at 780° C. and A_3 at 950° C.; 0·07 % carbon lowers A_3 to 850° C., but does not affect A_2. A_1 first makes its appearance in a 0·24 % carbon steel, and in the higher-carbon steels the three points run together and produce a marked discontinuity in the curve. The author considers the thermoelectric method to be quite as precise as any other method in determining the critical points of iron. F. C. A. H. L.

1499. *Cold-junction Corrections for Thermo-couples.* **P. D. Foote.** (Metallurgical and Chem. Engin. 11. pp. 329–333, June, 1913.)—A note on the methods of obtaining the corrections which must be applied to the readings of thermoelectric pyrometers when the cold junction during use is kept at the temperature of the room and not at the standard reference temperature such as the melting-point of ice. J. J. S.

1500. *Bismuth Thermopiles.* **W. W. Coblentz.** (Washington Acad. Sci., Journ. 3. pp. 357–360, June 19, 1913. Phys. Zeitschr. 14. pp. 683–684, Aug. 1, 1913.)—A summary is given of the results of various tests which have been made in connection with the improvement of the radiation sensitivity of thermopiles made of bismuth and some other metal. In the construction of thermopiles the most important desideratum is symmetry of the hot and cold junctions, as is the case with bolometers. The unexposed junctions must be covered with receivers having the same size and emissivity as the exposed junctions. Furthermore, all the junctions must be free from the supports, so that they may quickly take the temperature of the surrounding air which becomes heated by the incident radiations. The novelty in the thermopiles as constructed at the Bureau of Standards is the receiver, which like a bolometer can be made entirely opaque, and can be built up so as to present a large surface. In order to keep the resistance low the best diam. of bismuth wire is 0·1 mm. The proper diam. of silver or copper wire is 0·036 to 0·038 mm. An iron wire 0·036 mm. in diam. joined to bismuth was found to be about 9 % more sensitive radiometrically than a similar sample 0·0418 in diam. It is found that the thermal e.m.f. of various samples of Bi varies from 75 to 82 microvolts [incorrectly given as millivolts in the German] per degree with but little variation of resistance. Tests were made, one end of the bismuth wire being joined to silver and the other to iron, and both being covered with receivers of the same area. A sample of steel wire (0·036 mm. diam.) having an e.m.f. of 9 microvolts when joined with bismuth, has a radiation sensitivity about 28 % higher than the other junction of Bi-Ag. A sample of iron wire joined to bismuth having an e.m.f. of 13·5 microvolts was 28 % more sensitive than the junction of Bi-Ag. The bismuth wire cannot be rolled, but it can be easily flattened by pressing the wire between plate glass. When exposed to radiation it was found that the flat wire had a radiation sensitivity about 9 % higher than the round wire. Reduction of the gas pressure to 0·1 mm. pressure eliminates air currents and doubles the sensitivity. J. J. S.

1501. *Note on the Ballistic Galvanometer.* **T. J. I'a. Bromwich.** (Phil. Mag. 26. pp. 186–190, July, 1913.)—The formula, $Q = (2H/Gp)(1 + \lambda/2) \sin(\alpha/2)$, connecting the discharge and the swing of a ballistic galvanometer is often attributed to Maxwell. Maxwell, however, did not give it, and as it is only an approximation the author compares it with a more exact solution in terms of elliptic integrals. It is shown that $Q = (2H/Gp)(1 + \lambda\sigma/2)\sin(\alpha/2)$, where the values of σ are given in the following table :—

α.	σ.	α.	σ.
10	1·001	100	1·098
20	1·004	110	1·118
30	1·009	120	1·141
40	1·015	130	1·165
50	1·024	140	1·190
60	1·035	150	1·216
70	1·047	160	1·241
80	1·062	170	1·261
90	1·079	180	1·273

A. R.

1502. *Tubular Electrodynamometer for Heavy Currents.* **P. G. Agnew.** (Bureau of Standards, Bull. 8. pp. 651–658, March 1, 1913.)—In an instrument for transferring from alternating to direct current it is requisite that the torque shall be the same, and it is immaterial whether we make the current-distribution the same or the field due to the current the same. The latter method is adopted in the instrument described. The field " coil " consists of two coaxial copper tubes, thus giving a circular magnetic field in the space between the tubes. It is shown that if we have axial symmetry the magnetic field at any point is independent of the current-distribution. The tubes are horizontal, in order to allow of a vertical suspension, and the moving coils are placed astatically, one above and one below the inner tube. Phosphor-bronze suspensions are used and two air-damping vanes are provided. Experiments were made to determine whether the instrument is affected by distribution errors. At first it showed no such error up to 800 ∼, but after it had been in service some time a slight error was observed. This was due to a slight bending of the inner tube and was remedied. It is believed that the instrument is accurate to 0·05 per cent. At commercial frequencies no error can be detected, due to eddy currents being set up in the tubes by current in the moving system.
F. E. S.

1503. *Compressed-air High-pressure Voltmeter.* **C. E. Guye** and **A. Tscherniavsky.** (Archives des Sciences, 35. pp. 565–598, June, 1913.)—An electrometer suitable for measuring very high voltages is described, in which the increase of electric strength of air at high pressures is utilised. Roughly speaking the electric strength of air at a pressure of 10 atmos. is ten times greater than at ordinary pressure. Hence a voltmeter which will first spark across at 10,000 volts in air at atmospheric pressure will require 100,000 volts in air at 10 atmos. The authors point out the following advantages obtained by using compressed-air electrometers: The complete suppression, or at least the great diminution of brush discharges which usually adversely affect the working of electrometers; the suppression of the air currents due to electric discharges; the increase in the value of the coefficient of recombination of the ions, the diminution of their diffusion and mobility coefficients, and the reduction of the ionising effects. This secures that $\nabla^2V = 0$ at every element of the volume of the dielectric, so that we can use our mathematical equations. The great diminution in the size of the voltmeters is another advantage. The author's electrometer is a direct-reading instrument. The change in the value of the dielectric coefficient of air with atmospheric pressure is negligibly small. The logarithmic decrement increases very rapidly with the atmospheric pressure. On the other hand it is troublesome to make voltmeters capable of holding compressed air at high pressures, and so this type of instrument will probably only be used for measuring very high voltages when they have to be determined very accurately. [See also Abstract No. 488 (1910); also Watson, Abstract No. 1126 (1909).] A. R.

1504. *An Electrostatic Motor.* **E. Bloch.** (Comptes Rendus, 156. pp. 1751–1753, June 9, 1913.)—If instead of the ordinary suspension of the needle of a quadrant electrometer it is simply supported by a very mobile axis, the electric couple which is no longer balanced by an opposing couple due to torsion will drag the needle to the interior of one pair of quadrants. If at this moment the sign of the charge of the needle (or the sign of the charge of the quadrants) is reversed, the needle will continue to turn and will move within the other pair of quadrants. A new change of sign will cause the movement to continue and thus continuous rotation may be produced. The author explains how he realised this arrangement experimentally, using a commutator on the axis supporting the needle, and employing an alternating current to produce the changes of potential. Thus a synchronous electrostatic motor worked by alternating currents was obtained. Although the potential is high the current is limited to a very small fraction of an ampere. J. J. S.

1505. *Theory of Electrocapillarity.* **D. L. Chapman.** (Phil. Mag. 25. pp. 475–481, April, 1913.)—Mathematical.

1506. *Attraction between Coaxial Solenoids carrying Electric Current.* **G. R. Olshausen.** (Ann. d. Physik, 41. 2. pp. 278–288, June 3, 1913.)—A mathematical paper in which formulæ are deduced by which the attractive force between two coaxial solenoids carrying current may be calculated for all cases. T. P. B.

ALTERNATING CURRENTS AND MAGNETISM.

1507. *Maximum Value of Magnetisation in Iron.* **B. O. Peirce.** (Amer. Acad., Proc. 49. pp. 117–146, June, 1913.)—The value of the limiting magnetisation in iron has been stated variously at from 1390 (Rowland) to 1850 (du Bois and Jones). The author tested 25 different brands of iron by means of a solenoid method, great precautions being taken to ensure accuracy of all the measurements, and obtained values of I varying from 1588 to 1742. Five of the specimens gave values of I larger than 1700 for excitations of about 2800 gauss. In the course of the paper the theory of the use of condensers in the inductive secondary circuit is given, and curves are shown in which the reciprocal of the susceptibility is plotted against the field in the case of the results of du Bois, Roessler, and of the author. These give, except for small fields, a straight line in line with the origin. Micrographs of some of the specimens are shown. [See also Abstract No. 988 (1912).]

G. E. A.

1508. *Dependence of Remanent Magnetism on Temperature.* **A. Perrier.** (Archives des Sciences, 35. pp. 360–368, April, 1913.)—The quantities I, H, and t (temperature) are measured along three rectangular axes to give the surface $\phi(I, H, t) = 0$, the values of I being taken such that all the functions $I = f(t)$ differ, by a constant factor only, from $I_{\text{max.}} = f(t)$. It is then stated that the magnetisation in zero field varies with the temperature according to the same law as the magnetisation at saturation, and, hence, that the remanent magnetisation differs from the "spontaneous" magnetisation only by a constant factor. Another conclusion states that the residual magnetism should be the same, either with increasing or decreasing temperature. Ashworth's experiments are found to verify a part of these conclusions [see Abstract No. 752 (1912)]. G. E. A.

1509. *Variation in Torsion produced in Iron and Nickel Wires by an Alternating Magnetic Field.* **G. Ercolini.** (N. Cimento, 5. Ser. 6. pp. 180–201, March, 1913.)—The torsion of an iron or nickel wire is found to be appreciably altered by subjection to an alternating magnetic field, the variation produced increasing and diminishing with increase or reduction of the intensity of the field, and being greater as the angle of torsion is increased. The sign of the variation is the same as of that produced by a constant field. The action is twofold, there being a reduction in the elastic hysteresis in both metals, accompanied in the case of nickel by an increased torsion, and in the case of iron by a reduced torsion. The iron wires examined were 0·04 cm. in diam., and those of Ni 0·025 cm.; all were 25 cm. long. The alternating field ranged from 2·8 to 91·5 c.g.s. units. W. H. Si.

1510. *Effect of Rapidity of Variation of Field on Hysteresis.* **A. Schidlof** and **Mlle. C. Chamié.** (Archives des Sciences, 36. pp. 13–40, July, 1913.)—The question, whether magnetic alternating hysteresis is independent of the rapidity of description of the magnetic cycle, was tested experimentally, frequencies between 800 and 1200 per sec. being employed in magnetising an iron ring provided with primary and secondary circuits. The energy loss due to hysteresis in the iron is shown to be proportional to the deflection of the electrostatic electrometer employed as wattmeter. The conclusion drawn from the experimental results is that the effect of rapidity of variation of the applied field on the hysteresis is in every case very small. G. E. A.

1511. *Electromagnet with Ferro-cobalt Pole-pieces.* **P. Weiss.** (Comptes Rendus, 156. pp. 1970–1972, June 30, 1913. Lumière Électr. 23. pp. 81–82, July 19, 1913.)—Iron, which contains 11 magnetons per atom, forms with cobalt, which has 9, a compound Fe_2Co with 12 magnetons. This ferro-cobalt has a saturation value 10 per cent. higher than iron at ordinary temperatures. Owing to the difficulty of obtaining large enough solid pieces the points only of the pole-pieces were composed of Fe_2Co. The fields were compared when such poles were exchanged for similar ones made from Swedish iron. In every case there was an increase of the field of about 5 per cent. in favour of the ferro-cobalt pole-pieces. G. E. A.

1512. *Magnetic Study of Antimony Alloys with Tin and Lead.* **P. Leroux.** (Comptes Rendus, 156. pp. 1764–1766, June 9, 1913.)—Employing the magnetic balance of Curie and Chéneveau, the alloys Sb-Sn and Sb-Pb have been studied, and the results plotted on curves. An angular point is obtained for 50 % Sb in the first case, confirming the existence of the compound SbSn, and a compound of Sb and Pb containing 85–86 % Sb is also indicated. W. H. Si.

1513. *Magnetic Properties of the Alloys of Iron, Cobalt, Nickel, and Manganese with Boron.* **A. B. du Jassonneix.** (Eighth Internat. Congress of Applied Chemistry, 2. pp. 165–170, 1912.)—Measurement of the magnetic permeability of the various alloys of iron with boron [Abstract No. 1462 (1909)] shows that it attains a maximum when the composition corresponds with that of the boride, Fe_2B. Similar series of measurements could not be made with alloys of Ni and Co, owing to the small quantities of them available, but the few results obtained indicated that the magnetic permeability of Ni is diminished by alloying with boron, at all events at the ordinary temperatures; the boride Ni_2B is not attracted even by a strong magnet. Of the manganese borides, MnB and MnB_2, only the former possesses magnetic properties other than those possessed by manganese itself. The permeability of the various alloys reaches a maximum at 13–15 % of boron. Hysteresis measurements showed that the various alloys of iron and manganese with boron, as also the borides Fe_2B, MnB, MnB_2, and CoB, gives flatter cycles than soft-iron filings. Iron boride, Fe_2B, becomes non-magnetic at 740°; with falling temperature, it becomes magnetic at 730°. Both the borides of Fe and Co lose their magnetism at a lower temperature than the respective metals. T. S. P.

1514. *The Hall-effect.* **A. W. Smith.** (Phys. Rev. 1. Ser. 2. pp. 339–354, May, 1913.)—The influence of temperature on the Hall-effect and some allied effects have been studied in some magnetic alloys, those chosen being monel metal, nichrome, and three silicon steels. Monel metal contains about 68 % Ni, 1·5 % Fe, 1 % Mn, and 29·5 % Cu. Nichrome is an alloy of Ni, Fe, Cr, and Mn. The author found that an increase of temperature causes changes in the Hall-effect and in the Nernst-effect in monel metal and nichrome which are very similar to the changes produced in Ni, Fe, and Co under corresponding conditions. [Abstract No. 448 (1910).] The Nernst-effect and the Hall-effect in monel metal and nichrome depend on the temperature in essentially the same way. The addition of small quantities of Si to iron causes a large increase in the Hall-effect and a decrease in its temperature-coefficient. Under similar conditions there is at first a decrease in the Nernst-effect, then a reversal of its direction and an increase to a larger value in the opposite direction. Associated with this reversal of the Nernst-effect is the reversal of the thermo-e.m.f. against copper. In a transverse magnetic field the changes in the resistance of monel metal and nichrome are less in amount, but otherwise similar to those in the case of nickel. The influence of tension on the longitudinal change of resistance in a magnetic field in monel metal and in nickel is the same except as regards magnitude. Large quantities of occluded hydrogen do not change the Hall-effect in palladium. In the neighbourhood of 275° C. there is a molecular transformation of tellurium, after which the Hall-effect has about double its former value. The Hall-effect was measured in iron pyrites and galena. In these crystals the Hall e.m.f. is proportional to the magnetic field. J. J. S.

1515. *Stability of Residual Magnetism.* **N. H. Williams.** (Phys. Rev. 1. Ser. 2. pp. 360–381, May, 1913.)—The phenomena of residual magnetism are classified by the aid of analogies with mechanical elasticity. An oscillograph method was developed for plotting magnetic cycles by using a 60-∿ alternating current, the specimen being a steel wire in ring form. The following are among the results obtained:—In a given specimen, for any value of residual magnetism, there is a definite "elastic limit" or max. field that can be applied to the specimen without producing permanent demagnetisation; if any field not exceeding the limiting field be applied and then removed the specimen will return to its initial condition. Within the elastic limit magnetic stress and strain are approximately proportional, *i.e.* the demagnetisation is approximately proportional to the field intensity that produces it, provided that the specimen returns to its original remanence when the field is returned to zero. The hysteresis as indicated by the area of the curves is small, and is approximately the same for soft iron and hard steel. The extreme points of the stable demagnetisation and recovery curves lie inside the max. hysteresis curve. There is a well-defined upper limit beyond which the residual magnetism of an open magnetic circuit of steel cannot be made to pass. G. E. A.

1516. *Magnetic Viscosity.* **W. Luthe.** (Deutsch. Phys. Gesell., Verh. 15. 11. pp. 458–486, June 15, 1913. Extract of Dissertation, Halle.)—The question was investigated whether the effect known as magnetic viscosity, magnetic after-effect or delay, is not brought about wholly by retardation in the rise of the magnetising current caused by self-induction. The magnetic viscosity was measured for seven rings, and the effect was observed in iron, nickel, and cobalt. With a knowledge of the inductances of the circuit the observed effects can only be partially ascribed to induction in the primary and secondary, and then only in the case of very short time-intervals. The viscosity has not the same values for make and break. The case of nickel is distinguished by a great initial diminution in the effect, followed by a very gradual dying out. The effect is greatest when the permeability is at a maximum. G. E. A.

1517. *Magnetic Kerr-effect.* **W. Dziewulski.** (Phys. Zeitschr. 14. pp. 485–489, June 1, 1913.)—Compares Ingersoll's observations of the Kerr-effect obtained with equatorial magnetisation, when the lines of force are normal to the plane of incidence [Abstract No. 261 (1913)], with the values calculated from Voigt's theory. The agreement is fairly satisfactory, though in cobalt and nickel there is a displacement of the critical angle of incidence, which may, however, be due to a tarnishing of the reflecting surface. In steel the maxima actually attained fall short of the theoretical values. The author criticises Ingersoll's method of comparing his results with Wind's theory. E. E. F.

1518. *Kinetic Theory of Paramagnetism of Crystals.* **P. Weiss.** (Comptes Rendus, 156. pp. 1674–1676, June 2, and pp. 1836–1837, June 16, 1913.)—An expression is deduced which shows that in general the coefficient of magnetisation is not inversely proportional to the absolute temperature, but is a more complicated function of that quantity. It is also deduced that, in the general case, the mean of the coefficients of magnetisation, observed in three rectangular directions, obeys the Curie law. The author, hence, justifies his use of the coefficients of magnetisation in determining molecular moments. G. E. A.

1519. *Magneto-chemistry of Certain Ferric Salts and the Magneton Theory.* **B. Cabrera** and **E. Moles.** (Archives des Sciences, 35. pp. 425–457, May, 1913.)—Measurements of the specific susceptibilities of solutions of ferric chloride and nitrate and sodium ferric pyrophosphate give for the atomic susceptibility of iron a value varying with the concentration. This variation of χ_{Fe}^{a} constitutes a further confirmation of the chemical changes occurring in solutions, and may be explained by assuming that the number of molecules of the modified dissolved substance increases on dilution from zero to 100 per cent. of the total number of molecules. Conclusions drawn by previous investigators from the results of measurements at a single concentration are hence valueless. Calculation of the numbers of magnetons at infinite dilution confirms the law of integers advanced by Weiss, the numbers being either 25 or 27 for the three ferric salts mentioned above. With ferric chloride, the only salt for which sufficiently concentrated solutions were obtained, the number of magnetons approaches the integer 29, which agrees with the value obtained by Feytis for sublimed ferric chloride. In the case of ferric nitrate the course of the curve and the results obtained with acidified solutions indicate the same limiting number of magnetons. The instability and marked viscosity of solutions of sodium ferric pyrophosphate prevent these from being studied at high concentrations, but the limit here is apparently 27. The influence exerted on the magnetic properties by the addition to the above salts of varying proportions of either the acid or a salt with similar anion has also been investigated. It appears that the anion and the hydrogen ion of the acid act separately; the latter restores the modified molecule to its original condition, the number of magnetons then approaching 29, whilst the anion causes an increase, possibly a continuous one, in the susceptibility. T. H. P.

1520. *Influence of the Alps on the Secular Movement of the Elements of Terrestrial Magnetism.* **J. Maurer.** (Archives des Sciences, 36. pp. 5–12, July, 1913.)—The author has been occupied for many years with the utilisation of all the Swiss magnetic data available for making a graphic representation of secular variation, and thereby showing the modification of secular magnetic oscillations in the immediate proximity of the Alps. The author expresses his indebtedness to Wild, who from the commencement was inclined to the view that Alpine influence on secular magnetic variation was not improbable. Up to the present time the influence of a high mountain region had not been sufficiently established, and it was not till Brückmann's work that the law of change of terrestrial magnetic force with increasing altitude could be given; former studies by Forbes, Bravais, Martins, and Quetelet in the Alps, Kupffer in the Caucasus, and Humboldt in the Alps, being without result. It has been established that the variation of the magnetic elements from year to year is itself subject to great divergence, especially in the neighbourhood of maxima and minima. By a graphical representation (given in the paper) of all the recorded observations, the author believes it possible to determine the divergence in the secular variation of declination and inclination between Alpine stations and those situated farther north or south, *e.g.* at London, Paris, Rome, etc. An examination of the declination curves shows that as the Alps are approached the oscillation of the magnetic needle from the last point of inflection at the beginning of the last century appears sensibly more pronounced. The curves for Zürich, Basle, and Geneva take a more pointed shape, while the transition is sharper than for those at London, Paris, and Rome. Also the secular variation of declination when crossing the Alps from north to south seems to exhibit only a single high point of inflection for the last century. The results for inclination, however, do not exhibit any pronounced variation, and seem to be of very complex character. Small anomalies are therefore neglected, and judgment is reserved until more data are available. H. H. Ho.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1521. *New Method of Preparing Argon.* **J. Stark.** (Phys. Zeitschr. 14. pp. 497–498, June 1, 1913.)—When oxygen issues from a cylinder into a vacuum tube containing Hg vapour a reddish-yellow deposit of HgO appears on the glass. The canal-ray spectrum shows mercury and strong argon lines, but little oxygen, and no nitrogen. The commercial oxygen gained by evaporation of liquid air contains some 6% N and 4% Ar. The oxygen and nitrogen combine with Hg in the glow discharge, and leave the argon free. The author describes a simple arrangement for utilising this process in preparing spectroscopically pure argon. Not only nitrogen and oxygen are rendered active by the glow discharge, but also hydrogen and iodine vapour. E. E. F.

1522. *Miscibility of Liquids at Pressures up to 3000 Atmospheres.* **P. Kohnstamm** and **J. Timmermans.** (Konink. Akad. Wetensch. Amsterdam, Proc. 15. pp. 1021–1037, April 24, 1913.)—An apparatus is described which allows of the investigation by direct vision of the effects of pressures up to about 3000 atmos. on the critical solution temperatures of binary mixtures. Tabulated results are given of the values of *dt/dp* over various ranges of pressure for mixtures of: (1) hexane and nitrobenzene, (2) di-isoamyl and nitrobenzene, (3) American petroleum and nitrobenzene, (4) cyclohexane and aniline, (5) water and triethylamine, and (6) water and methyl ethyl ketone. These results are in complete accordance with those deduced theoretically during the past few years. In the case of mixture (6), it was found possible to effect the transition from partial to complete miscibility by change of pressure at constant temperature. T. H. P.

1523. *Some New Multiple Relations of the Atomic Weights of Elementary Substances; Classification and Transformations of Neon and Helium.* **H. Wilde.** (Manchester Lit. and Phil. Soc., Mem. 57. Part 3. No. 12 [11 pp.], 1912–1913.)—In several of the author's papers on the "Origin of Elementary Substances" (Ibid. 1878–1906. Chem. News, 38. p. 66 *et seq.*, 1878), special attention was directed to the seventh series of his classification, on account of the magnitude and importance of its primary members in the economy of nature, namely: nitrogen, silicon, iron, and gold. Silicon in combination with oxygen constitutes more than half the weight of the earth's crust. The arbitrary policy of several writers in doubling the atomic weights of four of the gaseous members of this series (neon, argon, krypton, and xenon) induced the author to review the multiple relations of the seventh series with the important result, (1) that six triads are formed out of the eight principal members of the series, in which the sum of the atomic weights of the extreme members is double the atomic weight of the means, and are all multiples of seven. Triads of atomic weights have been fully recognised by Dumas, Faraday, and others, as indubitable evidence of community of origin, of transmutation, and important factors in the classification of elementary substances.

Radium (as was indicated in the author's tables of elements some years previous to its discovery) is one of the synthetic transformations of helium, and is the next higher member of the series to barium, as was since confirmed by Mme. Curie. Helium is also shown in the author's table of 1878, as the analytic transformation ultimate of radium and other members of the second series of elements. The positions of helium and neon, as the transformation ultimates of the second and seventh series respectively, are further interesting in connection with the recent announcements that these elements have been found in glass vessels and tubes in which they had no previous existence [Abstract No. 1033 (1913)]. Assuming the reality of these observations, the phenomena not only admit of explication from the author's classifications, but also account for the discordant results obtained by the experimenters engaged in the research. One of the investigators could only find neon, while others, working independently, found helium alone, and in other cases a mixture of both gases. These results were of sufficient interest to induce the author to ascertain the composition of various glasses used in the arts.

The principal and most important constituent of the glasses tabulated by the author is silicon; the transformation ultimate of which is neon. The next important constituents are barium, calcium, and lead; all members of the second series of elements, the transformation ultimate of which is helium. The alkali metals, sodium and potassium, are constituents of nearly all glasses, and their transformation ultimates (with others of the first series) will be hydrogen and neon; but without helium. All the silicates of the first and second, and some of other series, are easily vitrified in small quantities in laboratory crucibles. Their spectra can then be examined during electrification in tubes (under suitable conditions of temperature and pressure) for the discovery of new elements, and the identification of those already known.

AUTHOR.

1524. *Great Advance in Crystallography.* **A. E. H. Tutton.** (Chem. News, 107. pp. 277–280, June 13; 289–292, June 20, and pp. 301–304, June 27, 1913. Discourse delivered at the Royal Inst. Nature, 91. pp. 490–494, July 10, and pp. 518–522, July 17, 1913.)—The author summarises the recent work of Federov, and of Barlow and Pope, and the more recent work of Friedrich, Knipping and Laue on the spot-photographs, resembling diffraction spectra, produced by X-rays after passing through plates of crystal. T. M. L.

1525. *On the System Phosphorus.* **A. Smits, J. W. Terwen** and **H. L. de Leeuw.** (Konink. Akad. Wetensch. Amsterdam, Proc. 15. pp. 885–890, April 24, 1913.)—The authors discuss the system phosphorus in the light of the new theory of allotropy [see Abstract Nos. 690 and 691 (1911)]. Phosphorus belongs to the type ether-anthraquinone. The critical point of the pseudo αP will probably lie below 422° C.; pseudo βP certainly melts above 610° C. (the m.p. of red P) so that the melting of the second pseudo component is probably 200° C. above the critical point of the first pseudo constituent. Some interesting experiments are described and an equilibrium diagram for the system is given. F. C. A. H. L.

1526. *Production of Diamonds in Electric Furnaces.* **F. P. Mann.** (Metallurgical and Chem. Engin. 11. pp. 361–363, June, 1913.)—An account of experiments made by E. de Boismenu at Paris in 1908 and described by him in a pamphlet: "Fabrication Synthétique du Diamant." Fused calcium carbide is electrolysed for hours in an electric furnace fitted with two horizontal carbon electrodes 24 cm. apart. "Enriched" carbide is afterwards found near the anode; further away the carbide is undecomposed, but near the kathode a black mass of carbon is observed, from which a few flakes of graphite and some irregular colourless crystals or globules can be isolated; these were pure carbon, according to Lacroix and Maquenne. The length of the crystals increased with the duration of the electrolysis, from 1·5 mm. in 6 hours to 2·7 mm. in 12 hours. The process is covered by the French Pat. No. 4566 of Aug., 1907. [For photographs of the diamonds produced, *see* Engineering, 96. p. 365, Sept. 12, 1913.] H. B.

1527. *Study of a Carborundum Furnace.* **W. D. Bancroft, L. V. Walker,** and **C. F. Miller.** (Amer. Electrochem. Soc., Trans. 22. pp. 73–86; Discussion, pp. 87–88, 1912.)—Curves are given showing the core temperature as well as the yield of carborundum, siloxicon, and graphite as a run proceeds. The work was restricted to a 20-kw. and a 30-kw. furnace. The normal charge consisted of 53·5 % sand, 40 % coke, 5 % sawdust, and 1·5 % salt. W. R. C.

1528. *Attack of Quartz by Vapours of Hydrofluoric Acid.* **A. Gautier** and **P. Clausmann.** (Comptes Rendus, 157. pp. 176–179, July 21, 1913.)—When trying to substitute quartz for glass in engraving processes, in order to render the etching action more uniform, the authors observed that a polished quartz surface, cut at right angles to the vertical axis, was not at all, or scarcely, attacked by vapours of HF even when the acid was very strong. It resulted that taking the corrosion of glass as 1000, that of most crystal faces of quartz would be 11 or 12, that of quartz cut at right angles to the axis 1; the corrosion of the triangular rhombohedral faces was 1 for the three faces of the direct rhombohedron, and 11 for the three others. Fused quartz suffered a corrosion of 100 on polished faces. H. B.

1529. *Alloying of Aluminium.* **C. H. Ivinson.** (Mech. Eng. 31. pp. 696–697, June 27, 1913. Paper read before the British Foundrymen's Assoc., June, 1913.)—The useful alloys of aluminium may be divided into three groups: (1) Aluminium containing not more than 10 to 25 % added metals. (2) Metals containing not more than 10 to 15 % Al. (3) Alloys of rare metals with Al, containing not more than 0·5 to 5 % added metal. Nickel when added to Al is stated to give unstable alloys, but the addition of a third element, such as copper, is an advantage. Mg-Al alloys containing 1 to 10 % Mg are much improved by the addition of 5 % Zn. Cerium, when added to Al, has a marked effect, 0·5 % increasing the tensile strength from 4·5 tons to 10·3 tons per sq. in. An alloy containing 2 % beryllium gave a tensile strength of 11·8 tons with an elongation of 10 %. Titanium and chromium alloys with aluminium are affected by sea-water and by ordinary atmospheric conditions. C. O. B.

1530. *Polymorphism of Zinc.* **P. N. Laschtschenko.** (Jurn. Russk. Fisik. Chimičesk Obščestva, 45. pp. 552–557, 1913.)—The author has measured the amounts of heat developed during the cooling of zinc in a tube of quartz glass from various temperatures ranging from 200° to 540° down to 15–15·5°. The curve having amounts of heat as ordinates and initial temperatures as abscissæ suddenly increases in steepness at 340–350°, which is in good agreement with the temperature of transformation as given by other observers. At the melting-point, 419–420°, the curve rises vertically through a certain distance, and then becomes virtually a straight line. The heat of transformation is about 0·19 cal. per gm. atom, and the latent heat of fusion about 1·78 cals. Although quartz exhibits a definite temperature of transformation at 575–580°, quartz glass contains no crystalline quartz, and hence shows no transformation point. T. H. P.

1531. *Variations of the Resilience of Copper and some of its Alloys as a Function of the Temperature.* **L. Guillet** and **V. Bernard.** (Comptes Rendus, 156. pp. 1899–1901, June 23, 1913.)—The work described in Abstract No. 301 (1910) has been applied to copper and its alloys with Zn, Ni, and Al at temperatures up to their melting-points. In the case of copper the resilience diminishes regularly with the temperature. The alloys often show a max. resilience at 100°–200° C. and a max. fragility at 300° to 400° C., which in some cases disappears again between 700° and 900° C. A 10 % zinc alloy containing no lead loses its fragility between 700° and 900° C., but the addition of 1·3 % lead results in the maintenance of fragility right up to the solidus. Aluminium alloys give irregular results. A 20 % Ni-Cu alloy shows a max. fragility at 800° C., after which the resilience increases. From the industrial point of view it is interesting to note that the temperature of rolling and forging often corresponds to the disappearance of fragility.

F. C. A. H. L.

1532. *Metallography of Refined Copper.* **E. S. Bardwell.** (Amer. Inst. Mining Engin., Bull. No. 79. pp. 1429–1441, July, 1913.)—A description is given of the method of determining oxygen in the refined copper used at the Boston and Montana Reduction Plant. The specimen, after suitable polishing, is etched by heating in a current of hydrogen at 800° for 4 or 5 mins. and allowed to cool in hydrogen. The structure of the etched specimen is clearly visible to the naked eye, the network of eutectic appearing as if depressed, and the copper areas stand out in relief. The method used for estimating the oxygen-content consists in projecting the image directly upon a piece of "Duplex" paper and tracing the outlines lightly with a hard pencil. The copper areas are next cut out with a sharp knife and weighed; the network of paper representing eutectic is also weighed, and the oxygen-content computed from the weights. The effect of oxygen on the conductivity of refined copper is considered, and it is shown that a decrease in oxygen-content coincides with an increase of conductivity, although the curve obtained is very irregular when taken from samples in which the amounts of other impurities vary. The results of a few tests on copper in which the oxygen increases whilst the other impurities remain constant, show that the conductivity increases steadily as the oxygen decreases. C. O. B.

1533. *Palladium-Antimony Alloys.* **W. Sander.** (Zeitschr. anorg. Chem. 75. pp. 97–106, 1912. Rev. de Métallurgie, 10. pp. 875–876, July, 1913.)—A thermal analysis of Pd-Sb alloys, fusing them in an electric furnace in porcelain tubes traversed by a current of nitrogen, shows the existence of compounds Sb_2Pd, SbPd, Sb_2Pd_5, and $SbPd_3$, melting at 676°, 805°, 889°, and 1218° C. respectively. Photomicrographs, which are reproduced, confirm these results. W. H. Si.

1534. *Gold-Silver Alloys.* **U. Raydt.** (Zeitschr. anorg. Chem. 75. pp. 58–62, 1912. Rev. de Métallurgie, 10. p. 875, July, 1913.)—Thermal analysis of the system Au-Ag gives results similar to those obtained by Jänecke [Abstract No. 91 (1912)], which are also confirmed by micrographic examination. W. H. Si.

1535. *Influence of Annealing on the Structure of Alloys.* **A. Portevin.** (Rev. de Métallurgie, 10. pp. 677–721, June, 1913.)—The author has attempted to place on record the structural changes taking place in alloys during the process of annealing which consists essentially of heating followed by slow

cooling. Properly speaking, annealing consists in heating to above the transformation point; heating to below this temperature constitutes the process of tempering. The effect of tempering is determined by the temperature and time of heating, and is not affected by the rate of cooling, while the effect of annealing depends exclusively on the rate of cooling. The modifications brought about by annealing are as follows:—(1) restoration of mechanical equilibrium by destruction of internal tensions; (2) restoration of the physico-chemical equilibrium as determined by the equilibrium diagram; (3) restoration of structural equilibrium, appearance of the equilibrium microconstituents, coalescence of the structural elements and increase in the chemical heterogeneity in fields of two phases; and (4) restoration of crystalline equilibrium, during which a general or local increase of grain size occurs. Considerable study has been given to the mechanism of annealing after hardening (rapid cooling), deformation and slow cooling, and the results show that annealing has a complicated effect on the internal architecture of alloys and is made up of a number of superimposed effects. All the structural modifications are reproduced in the chemical, physical, and mechanical properties of the alloys.
F. C. A. H. L.

1536. *Manganese-Silver Alloys.* **G. Arrivaut.** (Comptes Rendus, 156. pp. 1539–1541, May 19, 1913.)—From a study of the thermal, electrical, chemical, and microscopical properties of Mn-Ag alloys, the author concludes that Mn and Ag form a definite compound $MnAg_3$, which gives with Ag a continuous series of mixed crystals, and whose limit of miscibility in the liquid state with Mn is about 80 % of Mn. This confirms a previous communication of the anthor's but is contrary to the results of Hindrichs [Abstract No. 161 (1909)].
W. H. Si.

1537. *Cerium-Aluminium Alloys.* **R. Vogel.** (Zeitschr. anorg. Chem. 75. pp. 41–57, 1912. Rev. de Métallurgie, 10. pp. 376–377, July, 1913.)—Thermal analysis of Ce-Al alloys indicates the formation of compounds corresponding to Ce_3Al, CeAl, $CeAl_2$, and $CeAl_4$. Accurate figures cannot be given, as the Ce used was only of 98·5 % purity, but the melting-points of $CeAl_2$ and $CeAl_4$ are about 1460° and 1250° respectively. All the alloys are much less pyrophoric than those of Ce with Sb and Pb. [See Abstract No. 98 (1912).]
W. H. Si.

1538. *Thermal and Microscopical Examination of Standard Steels.* **G. K. Burgess, J. J. Crowe, and H. S. Rawdon.** (Amer. Inst. Mining Engin., Bull. No. 78. pp. 1093–1098, June, 1913.)—Heating- and cooling-curves by the inverse rate method are given for eight steels, carbon 0·08 to 1·45 %, and manganese in six cases not over 0·26, and in the others 1·16, and 1·21 % respectively. These are Howe's standard commercial steels mentioned in his paper "Life History of Network and Ferrite Grains in Carbon Steel" (Amer. Soc. for Testing Materials, Proc. 11. pp. 262–386, 1911). Simultaneous observations by the differential method gave substantially the same results. A few photomicrographs are given. The paper is for the rest a record of the observations of the critical temperatures and structures, and it is found that impurities appear to mask A_3 and A_2, whilst the effect of increasing Mn, as is generally known, is to lower A_1, and to increase the lag at this point. The vacuum in the furnace for taking the thermal curves was usually better than 0·1 mm., yet there was considerable surface decarburisation of the specimens. The action of Mn in hindering the formation of lamellar pearlite was found in the steel containing carbon 0·46 and manganese 1·21 %.
F. R.

1539. *Shock Tests of Cast Steel.* **J. H. Hall.** (Amer. Inst. Mining Engin., Bull. No. 79. pp. 1247–1256, July, 1913.)—Untreated steel castings of about 0·2 % carbon gave low results in the shock test (Frémont machine), about 6 kg.-m. absorbed. A number of results show the improvement brought about by holding the castings for a few hours at about 900° C., then quenching, followed by reheating to 680° and air cooling. It is found that the improvement is much greater nearer the outside than within the casting, where the rate of cooling in quenching is slower. For example, pieces cut from a cast-on test-bar measuring 3 × 3 × 2 in. varied from about 33 kg.-m. at the outside to 10 on the inner side of the test-bar. It is stated that no difference is perceptible between the corresponding microstructures, but the photomicrographs given do not bear upon this doubtful conclusion. Satisfactory tensile tests were obtained corresponding to low shock-test results. Falling weight tests upon a casting confirmed the small shock-tests. The quenching and reheating treatment is recommended for steel castings which are liable to shock in service. F. R.

1540. *Preliminary Note on the Critical Ranges A3 and A2 of Pure Iron.* **G. K. Burgess** and **J. J. Crowe.** (Washington Acad. Sci., Journ. 3. pp. 329–332, June 4, 1913.)—The authors have determined the inverse rate and derived differential heating- and cooling-curves of five different samples of pure electrolytic iron of the order of 99·97 % purity. All the samples showed Ac_2 as pronounced as Ar_2, and samples remelted *in vacuo* to remove gases showed that the maxima of Ac_2 and Ar_2 are identical in position. There are indications, however, that A2 and A3 are different in kind. [See also next Abstract.] F. C. A. H. L.

1541. *The Critical Ranges of Pure Iron with Special Reference to the A2 Inversion.* **H. C. H. Carpenter.** (Iron and Steel Inst., Journ. 87. pp. 315–326; Discussion and Correspondence, pp. 327–360, 1913. Engineering, 95. pp. 651–653, May 9, 1913.)—The author has made experiments on repeated heating- and cooling-curves of pure electrolytic iron containing only 0·033 % total impurities in order to test the truth of Benedicks' theory on the nature of the A2 inversion. All the cooling-curves show Ar_2, but after removing the dissolved hydrogen, Ac_2 cannot be detected on the heating-curves. From the experiments the author concludes that A2 as an independent critical point or range does not exist. The point on the cooling-curves is the temperature at which the γ iron, rendered metastable by contact or association with impurities, becomes unstable and reverts to α. From this it is further concluded that if the last traces of impurities were removed iron would cease to show even the faint indications of Ar_2. The mean temperature of Ac_3 is 916° C., and of Ar_3 is 888° C., while Ar_2 occurs about 742° C.; the actual temperature depending on the actual conditions of the test. F. C. A. H. L.

1542. *The Critical Points of Iron.* **W. Broniewski.** (Comptes Rendus, 156. pp. 699–702, March 3, 1913.)—Numerous researches have been conducted on the critical points of iron, but since the samples used were of indifferent purity, the results are not strictly comparable. Experiments have been carried out on pure electrolytic iron to determine its thermal e.m.f. against copper and platinum, its electrical resistance and its dilatations as functions of the temperature. The thermal e.m.f. curves show critical points at 730° and 1020° C. The electrical resistance curve shows continuous changes of direction between 750° and 850° C. and between 950° and 1020° C. which are difficult to associate with definite critical points. A sudden contraction is indicated at 950° C. on the dilatation curve, while the cooling-curves show an arrest point at 890° C. and a change of direction at 700° C. These results are in agreement with the hypothesis enunciated by Benedicks to the effect that β iron is a solid solution of γ in α iron, the change in direction in the electrical resistance curve corresponding to the maximum of the solid solution. The change in direction between 950° and 1020° C. is attributed to the formation of a new solid solution β'. α iron is stable below but commences to change at 730° C., while above 1020° C. the γ form is stable. Between 730° and 950° C. there is a solid solution of β' in α iron and between 950° and 1020° C. the solid solution of β' in γ iron exists. Further work on a similar series of carbon steels is required before these results can be admitted as definite. [See Abstract No. 1086 (1913).] F. C. A. H. L.

1543. *Determination of the Position of Ae_3 in Carbon-Iron Alloys.* **H. M. Howe** and **A. G. Levy.** (Amer. Inst. Mining Engin., Bull. No. 78. pp. 1075–1092, June, 1913.)—The position of Ae_3 (the equilibrium temperature of A_3 in pure iron-carbon alloys) has been determined in a series of fourteen hypo-eutectoid steels, one highly phosphoric and four rich in Mn, by noting the temperature at which reabsorption of pro-eutectoid ferrite took place completely after 30 minutes' heating and the temperature at which precipitation begins. The ferrite was first massed by heating to above 1200° C. and slowly cooling. Reabsorption results are more harmonious than the results of precipitation experiments, but the two sets of results agree very well with each other and also with the results of thermal experiments. When absorption takes place during steadily rising temperature, ferrite preserves its network better than when absorbed at constant temperature. Phosphorus raises A_3, while Mn appears to exert no effect micrographically but has a distinct lowering effect thermally. The line representing Ae_3 runs from about 915° C. for pure iron to 765° C. in a 0·5% carbon alloy, whence it changes its direction to 725° C. in a 0·9% carbon alloy. F. C. A. H. L.

1544. *Ae_1, the Equilibrium Temperature for A1 in Carbon Steel.* **H. M. Howe.** (Amer. Inst. Mining Engin., Bull. No. 78. pp. 1067–1074, June, 1913.) —The author discusses the values for Ac_1 and Ar_1 obtained by various workers from 1904 onwards. There is evidence to show that Ae_1 may be as high as 731° C. or as low as 700° C., but by excluding the less-supported evidence it is concluded that Ae_1 lies between 715° and 723° C., the weighted average of the results being 723° C. F. C. A. H. L.

1545. *Discussion of Existing Data as to the Position of Ae_3.* **H. M. Howe.** (Amer. Inst. Mining Engin., Bull. No. 78. pp. 1099–1136, June, 1913.)—The chief existing data as to the position of Ae_3 [see preceding Abstract] are discussed at some length. From the industrial point of view Ae_3 is probably the most important line in the iron-carbon diagram, since it represents the temperature at which "grain refining" takes place. Because of slower heating and soaking the industrial A_3 must lie nearer to the equilibrium temperature than the A_3 of thermal curves which are usually determined on small sections heated or cooled relatively quickly. Manganese increases lag, always lowering the Ar points and often raising the Ac points. This widens the gap between the Ar and Ac points, and the inference is that the Ae points are lowered in consequence. The effect on the eutectoid carbon-content is doubtful, recent results of Burgess and Crowe pointing to an increase rather than a decrease in this figure. Phosphorus raises Ac_3. The causes of error in the determination of the critical points are lag, surface decarbonisation, persistence of solidificational segregation and transformational segregation, precipitation of "quenching" ferrite or cementite, mistaking martensite for ferrite, failure to detect first or last traces of the pro-eutectoid element, and failure to identify first or last traces of retardations. These causes and their possible avoidance are discussed. A weighted average of the more important determinations shows that the temperature for Ae_3 can be calculated from the formula $T^\circ = 917^\circ - 806 \times c$ for the line GO and $T^\circ = 820 - 105{\cdot}5 \times c$ for the line OS of the iron-carbon diagram. This implies that GOS should be situated as follows :—

	Carbon %.	Temperature.
Point G	0	917° C.
Point O	0·483	769° C.
Point S	0·9	725° C.

F. C. A. H. L.

1546. *Growth of the Grains in Metals by Annealing after Cold Working.* **F. Robin.** (Rev. de Métallurgie, 10. pp. 722–757, June, 1913.)—The author has continued the work described in Abstracts Nos. 184 and 285 (1913) and has studied the growth of a number of commercially pure metals as a result of annealing at various temperatures after cold working. Maximum growth appears to take place at temperatures just below the commencement of annealing and the fusion point. Between these two temperatures, which, of course, vary for each metal a minimum growth is obtained. Cold working of normal grains appears to give rise to germinal grains which have the power of development either because they are endowed with a special energy, or, more probably, because the normal grains have less energy of development after annealing. In the case of local deformation the number of "germs" in the immediate area of deformation is large and growth is interfered with. In the surrounding region, however, growth occurs very rapidly. Growth is affected by the thickness of the plate; the amount of growth which can take place appears to be related to the space available in one direction. There is a striking irregularity in the phenomenon comparable with that in physiological growth, showing that there are still a number of circumstances which are not yet properly understood. Examination of a piece of metal which has been locally deformed and annealed can lead to information as to the previous treatment of the metal. The fact that cold work gives rise to a discontinuity in a property of a metal is evidence in favour of the loss of the crystalline state in a hardened metal. The author discusses the industrial importance of the subject and points out that the phenomenon may lead to fragility in some metals and fissuration by corrosion in others. It may be destroyed in steel by heating to above 900° C. and slowly cooling, and by the addition of small quantities of certain impurities to other metals. F. C. A. H. L.

1547. *Influence of Metalloids on the Properties of Cast Iron.* **H. I. Coe.** (Iron and Steel Inst., Journ. 87. pp. 361–372; Correspondence, pp. 373–381, 1913. Engineering, 96. pp. 97–99, July 18, 1913.)—The influence of varying quantities of manganese, sulphur, and phosphorus on cast irons containing different proportions of carbon has been determined by an investigation of their hardness, transverse and tensile strengths, and their microscopic features. Silicon increases the graphite separation, decreases the hardness and strength, and affects the deflection irregularly. Manganese increases the stability of the carbide and also exerts a direct hardening influence. Addition of Mn to an iron containing 2 % Si decreases the combined carbon, the effect reaching a maximum at 0·5 %, beyond which the percentage of combined carbon is again increased. The softening influence of small additions of Mn is due to the precipitation of secondary graphite. With low Si sulphur retains the carbon in the combined form. Sulphur increases the transverse and tensile strengths and at the same time increases the deflection, probably by modifying the dendritic structure. Up to 1 % phosphorus has a slight strengthening action, but the addition of 2 % results in a hard, weak, and brittle material. The microstructures and cooling curves of the alloys are also described. F. C. A. H. L.

1548. *Studies in the Cold Flow of Steel.* **P. Longmuir.** (Iron and Steel Inst., Journ. 87. pp. 93–111; Discussion and Correspondence, pp. 112–117, 1913. Mech. Eng. 31. pp. 706–708, June 27, and 32. pp. 32–34, July 11, 1913. Engineering, 95. pp. 716–719, May 23, 1913. Abstract.)—The paper is a continuation of the one dealt with in Abstract No. 123 (1912). It has been found possible to draw a steel containing 0·1 % C, 0·3 % P, and 0·1 % S from 0·201 to 0·024 in., and in so doing to raise its max. stress from 36 to 112 tons per sq. in. Evidently the presence of relatively large quantities of S and P does not retard flow, but the resulting material is likely to be unreliable under shock. The simultaneous presence of 2·5 % Si and 0·75 % Al in a 0·25 % carbon steel does not materially affect flow, provided annealing and cleaning are carried out properly. Such material possesses high magnetic permeability and electrical resistivity. High-carbon steels containing free cementite must be drawn with light draughts interspersed with frequent annealings. Both pearlite and ferrite flow freely, but it is doubtful if cementite flows at all in the true sense of the word. Superficial oxidation and precipitation of free carbon are to be avoided, since high-carbon wires are only employed because of their ability to harden after quenching; when high tensile strength alone is required it is obtained by suitable cold working rather than by the use of a high-carbon steel. Heat treatment removes the effect of cold work, but nevertheless there is a steady fining of the structure as the wire diminishes in diam., in spite of the frequent annealings. Successful flow demands an initially sound and homogeneous hot-rolled section. Overworking or the presence of segregated cores may give rise to "cupping" (internal rupture), brought about by the outer skin flowing more rapidly than the core. This has been studied by the preparation of artificially segregated billets containing high carbon and high sulphur and phosphorus cores. Tensile tests and microscopic examination showed that the composite rods drew well and showed no signs of cupping unless drawn to destruction. It was observed that the central core did not maintain its original round form during drawing. F. C. A. H. L.

1549. *Separation of Graphite in Iron-Silicon Alloys.* **G. Charpy** and **A. Cornu.** (Comptes Rendus, 156. pp. 1616–1618, May 26, 1913.)—It is known that carbon combined with iron tends to separate in the form of graphite when the metal is annealed at suitable temperatures, and that the separation is aided by the presence of Si, which appears to play the part of a catalyser. Experiments have been made on a soft steel of the type used in the construction of dynamo machinery, and having the composition C, 0·14 to 0·15 %; Si, 3·80 %; S, 0·018 %; P, 0·03 %; and Mn, 0·35 per cent. Annealing at

V.1
191

800° C. converts the whole of the carbon into graphite, but at 900° C. no graphite is produced. The microstructure developed at the latter temperature shows a larger proportion of pearlite than exists in a steel of the same carbon-content but containing no Si. This indicates that in high-silicon steels the eutectoid composition is considerably below 0·8 % carbon. The interval of temperature in which graphite is deposited varies with both the carbon and silicon contents. Below 3 per cent. Si the formation of graphite never occurs in low-carbon steels, but in a steel containing 0·4 % C. and 3·5 % Si separation of graphite occurs at 750° C. The interval in which separation of graphite can take place lies between a lower limit T, the temperature of transformation of cementite into graphite, and an upper limit T′ at which the solubility of graphite in the alloy is equal to its total content of carbon. T is lowered both by increasing the carbon and silicon contents. In alloys low in both Si and carbon T′ is lower than T and no graphite separation can take place. When T′ becomes higher than T, graphite separation can take place and the temperature interval increases with the carbon and silicon contents.

F. C. A. H. L.

1550. *Points of Transformation of Nickel-Chrome Steels.* **L. Guillet.** (Comptes Rendus, 156. pp. 1774–1776, June 9, 1913.)—It does not appear to be possible to deduce the quaternary diagram of the nickel-chrome steels from the ternary diagrams in the manner possible with Ni-Mn steels. In order to determine which of the nickel-chrome steels are sensitive to air-hardening, fifty samples of varying composition have been examined thermally and microscopically. Metallographic examination shows that increase of Ni with constant Cr and carbon contents, increases the tendency towards the eutectoid structure, *e.g.* a steel containing 0·25 % C, 2·4 % Ni, and 0·66 % Cr has a structure similar to that of a 0·75 % carbon steel, while a steel containing 0·3 % C, 0·78 % Cr, and no Ni has the appearance of a 0·35 % carbon steel. The effect of Cr on Ni steel depends on the content of C and Ni, *e.g.* 0·6 % Cr does not lower the critical points of steels containing 0·08 to 0·25 % C and 2·5 to 3·4 % Ni, but the presence of 1·2 % Cr in a steel containing 4 to 6·25 % Ni produces a considerable augmentation of the hysteresis.

F. C. A. H. L.

1551. *Experiments on the Annealing of Worked Products.* **L. Guillet.** (Rev. de Métallurgie, 10. pp. 665–676, May, 1913.)—Experiments made on the annealing of nickel and steel wires show that complete annealing takes place at 700° to 750° C. in the case of Ni, at 750° to 800° C. in the case of hard steel, and at 700° to 750° C. in the case of semi-hard and soft steels. It is therefore certainly not necessary to heat to the temperature of the highest critical point in order to anneal. The effect of the degree of working on the temperature of annealing is so slight as to make its existence doubtful. Brass anneals between 350° and 400° C. and semi-hard steel between 650° and 750° C. regardless of the degree of working. The influence of time is also very limited.

F. C. A. H. L.

1552. *Divergences between Structure and Composition of Certain Steels.* **Brès.** (Rev. de Métallurgie, 10. pp. 797–807, July, 1913.)—The author briefly reviews the work of Belaiew [Abstract No. 185 (1913)] and from it concludes that in order to obtain regular and comparable results from steels of the same type they must have the same initial structure. Further, two steels of identical composition but with different initial structures may behave like two different steels. Examination of four nickel-chrome steels of similar composition revealed widely different mechanical properties, which differences persisted through all manner of thermal treatment. The microstructures were quite compatible with the differences in mechanical properties, and ultimately it was found that there was a distinct difference in the structures of the original ingots. Differences in properties between Bessemer and open-hearth steel of the same composition and between crucible or electric steel and open-hearth steel of similar purity are well known. These differences apparently arise during manufacture, and the determining factors appear to be (1) the temperature of melting and refining, (2) the temperature of casting, and (3) the rate of cooling down to the solidus, which determines the mode of formation of the primary crystals. F. C. A. H. L.

1553. *Exothermic Steel.* **W. W. Clark** and **P. Kemery.** (Metallurgical and Chem. Engin. 11. pp. 207–209; Discussion, p. 209, April, 1913. Paper read before the Amer. Electrochem. Soc.)—The authors have made independent investigations of the process recently described by Amsler [see Abstract No. 136 (1913)]. Numerous experiments have failed to give any notable quantity of iron. There is no action exerted by the bauxite and felspar beyond a fluxing action, and any reduction is brought about by the carbon present. F. C. A. H. L.

1554. *Constitution of Liquid Amalgams.* **J. H. Hildebrand.** (Amer. Chem. Soc., Journ. 35. pp. 501–519, May, 1913.)—A formula given previously for the e.m.f. of liquid amalgam concentration-cells is integrated by the aid of the vapour-pressure law and applied to those amalgams for which data are available. The e.m.f. and vapour-pressure measurements agree in showing that in amalgams the zinc exists uncombined with the mercury but associated according to the equation: $2Zn = Zn_2 + 2400$ joules. With lead and tin amalgams the same formula applies but with a different constant, corresponding to a much greater degree of association. The measurements on thallium amalgams correspond to the formula derived for the cases where the solute combines with the mercury. The compound indicated in this case is $TlHg_3$, which gives evidence of breaking up into some simpler compound, probably $TlHg_2$ in the more concentrated amalgams. Indium amalgams seem to contain $InHg_4$ breaking down into some simpler compound in the more concentrated amalgams. Cadmium amalgams seem to contain both free Cd and the compound CdHg, in proportions depending on the law of mass action. In the most dilute amalgams ⅔ of the cadmium is combined to form CdHg. T. M. L.

1555. *Vapour Pressure of Liquid Tin Amalgams containing Mercury.* **A. Sieverts** and **H. Oehme.** (Ber. Deut. Chem. Gesell. 46. 6. pp. 1238–1246, 1913. Chem. News, 108. p. 12, July 4, 1913. Abstract.)—That diatomic gases dissolve in solid and liquid metals in quantities proportional to the square root of the gas pressure, as shown by the authors, might be explained by the assumption that the dissolving gas molecule splits into two atoms. Monatomic gases should dissolve in quantities proportional to the gas pressure, but experiments with helium and argon failed, because these gases would not dissolve at all. Hence experiments were made with tin (which is easily fused and has hardly any vapour pressure) and monatomic mercury vapour in amalgams containing from 0·3 to 3 per cent. of Hg. Their vapour pressure varied between 2 and 70 mm. for the range 300° to 360°, and the vapour pressure was also found proportional to the mercury concentration, in accordance with Henry's law, in two further series of experiments with amalgams of 2 and 10 per cent. at 515° and 528°. The distribution law would hence be applicable to solutions of gases in metals. H. B.

1556. *Association Phenomena in Certain Gaseous Mixtures.* **A. Schulze.** (Deutsch. Phys. Gesell., Verh. 15. 12. pp. 488–496, June 30, 1913.)—When acetone and chloroform vapours are mixed, a mutual association takes place. At 80° and a total pressure of 1 atmo. and with a molecular mixture of the two substances, the latter combine to the extent of 0·37 molecules per cent. From this result it follows that, in liquid mixtures of acetone and chloroform, the same compound exists in considerably increased amount, as has indeed been assumed from the divergent behaviour of the physical properties of such mixtures. With the mixtures ether-benzene and benzene-chloroform no chemical compound could be detected in the gaseous phases. Increase of pressure occurs on mixing vapours of ether and carbon disulphide, marked association of the carbon disulphide being thus indicated. Various other properties are mentioned which must be referred to the association of pure liquids and vapours [see Abstract No. 298 (1913)]. T. H. P.

1557. *Energy-changes during Photochemical Processes in Gases.* III. *Photochemical Deozonisation.* **E. Warburg.** (Preuss. Akad. Wiss. Berlin, Ber. 34. pp. 644–659, 1913.)—In studying photochemical reactions, the author divides the amount in molecules of any end-product by the quantity of radiant energy absorbed in its formation. This magnitude, which is termed the "specific photochemical action" for the particular end-product, has been determined for the decomposition, by means of light of known wave-lengths, of ozone mixed with oxygen, nitrogen, or helium. When a dry solution of ozone in oxygen is deozonised, the specific photochemical deozonisation diminishes with diminishing ozone-concentration while the latter is high but is independent of the concentration for dilute solutions of ozone in oxygen. Similar behaviour is shown by a dry solution of ozone in nitrogen, but in this case the specific photochemical action is much larger than with ozone-oxygen mixtures, the limiting value for low concentrations being indeed 8·8 times as great. Further, the specific photochemical deozonisation in moist oxygen-ozone mixtures is approximately twice as large as in the corresponding dry mixtures. In the concentrated ozone-oxygen mixtures, the photochemical action decreases with the intensity of the illumination. The fact that, in concentrated ozone mixtures, the deozonisation is greater than theory would indicate, is to be attributed partly to the effect of the heat of deozonisation. Only for dilute ozone-mixtures, with a total pressure of about 1 atmo., can the secondary reactions be determined. The behaviour of these mixtures furnishes a new confirmation of Einstein's photochemical equivalent law [see Abstracts Nos. 1046 and 1689 (1912)]. T. H. P.

1558. *Calculation of Equivalent Conductance at Infinite Dilution.* **S. J. Bates.** (Amer. Chem. Soc., Journ. 35. pp. 519–535, May, 1913.)—It is shown that the equations used by Kohlrausch and A. A. Noyes for determining Λ_0 values involve the assumption that the expression $(C)^2\gamma/C(1-\gamma)$, for the "ionisation constant," becomes zero at zero concentration. This is equivalent to the assumption that none of the four curves obtained by plotting C or $C\Lambda$ against Λ or $1/\Lambda$ cross the Λ or $1/\Lambda$ axis, but that all touch the axis tangentially at the point chosen as Λ_0 or as $1/\Lambda_0$. A graphic and an algebraic method are given for determining the value at any given concentration of the exponent n in Storch's equation. Alike for weak, medium, and strong electrolytes n becomes with decreasing concentration more nearly equal to the value required by the law of mass action. Lower and upper limits for Λ_0 can be determined. In the case of the uni-univalent salts for which data were determined by Kohlrausch for solutions as dilute as 0·0001 normal the uncertainty in Λ_0 is not over 0·1 %. The lower limit is determined by assuming that the law of mass action holds from the lowest part of the experimental range of concentration down to infinitely dilute solutions. The upper limit is the largest value which may be taken for Λ_0 which will not necessitate the assumption that the ions, the undissociated molecules, or both are more abnormal in very dilute solution than they are in the lowest part of the experimental range of concentration; in general, the values obtained by the methods of Kohlrausch and of Noyes are greater than this upper limit. A graphic method is described by means of which an upper limit and a "probable" value for Λ_0 may be determined. The limiting values and the "probable" values for a number of the more common salts show good agreement, but the resulting Λ_0 values are smaller than those generally employed. T. M. L.

1559. *Preparation of Conductivity-water.* **R. Bourdillon.** (Chem. Soc., Journ. 103. pp. 791–795, May, 1913.)—By passing a current of purified air through the steam obtained from tap-water, the author has been able to prepare water having a conductivity of only 0·11 gemmho. The water (7 to 8 litres) is mixed with potassium hydrogen sulphate (5 gm.); the steam is passed through a long spiral and an empty bottle acting as a spray-trap, and is condensed in a vertical tube of block tin. The first litre of the distillate is rejected, and it is advisable to stop the distillation whilst 2 or 3 litres of water still remain in the boiler to prevent incrustation, but it is possible to collect a middle fraction of some 5 litres having a conductivity of 0·09 to 0·11 gemmho, rising only occasionally to 0·12. Such water must be used in an air-tight cell, but under these conditions the conductivity rises only 0·004 gemmho per hour, or if the cell has recently been used for a dilute salt solution, about 0·01 gemmho per hour. T. M. L.

1560. *Determination of Electrical Conductivity of Solutions.* **H. Hartley** and **W. H. Barrett.** (Chem. Soc., Journ. 103. pp. 786–791, May, 1913.)—A comparison was made of the electrical resistance of electrolytes as measured (*a*) with an induction coil and telephone, and (*b*) with a commutator and galvanometer. The figures were not concordant, the ratio of the two values varying (1) with the construction of the commutator, (2) with its speed, (3) with the magnitude of the resistance, and (4) with the form of the cell. The resistances measured by the commutator are always higher, but approach the telephone-values as the speed is increased. This is in accordance with the known form of the current-wave of the induction coil, which is really of very short duration in comparison with the nominal period of the coil; the polarisation effects are therefore no greater than with a commutator running at a frequency many times greater than that of the note which is heard in the telephone. A conductivity cell for very dilute solutions is also described; it is closed by a cap, ground on outside, and the solution is protected by passing in a current of purified air whenever the cell is opened. T. M. L.

1561. *The Free Energy of Chemical Substances.* **G. N. Lewis.** (Amer. Chem. Soc., Journ. 35. pp. 1–30, Jan., 1913.)—The present paper is of an introductory character, and deals with the general methods used in calculating the free energy of substances—notation, thermodynamic method of treatment, etc. A. F.

1562. *Potential of the Lithium Electrode.* **G. N. Lewis** and **F. G. Keyes.** (Amer. Chem. Soc., Journ. 35. pp. 340–344, April, 1913.)—The method used was the same as for potassium and sodium [see Abstract No. 969 (1912)], but the solvent ethylamine was replaced by propylamine, which dissolves lithium iodide but not the metal, at any rate not when the iodide is present. A cell consisting of Li, Li-amalgam (prepared by electrolysis of LiCl, the amalgam of 0·085 % of Li being collected in a vacuum), and solution of the iodide in propylamine—all operations carried out in vacuum—yielded an e.m.f. of 0·9502 volt, which decreased to 0·9457 in 8 days. The potential of the amalgam in aqueous solution was 2·3952, and allowing for the liquid potentials the final electrode potential of lithium was 3·3044 volts, the highest value so far observed, the values for Na and K being 2·9981 and 3·2084 volts, whilst the heats of solution of the metals in the several dilute amalgams used were, in the same order, Li, Na, K: — 19,605, — 19,790, — 26,050 cals. H. B.

1563. *Alkaline Accumulators.* **E. Friederich.** (Elektrochem. Zeitschr. 19. pp. 301–304, Feb.; 333–336, March; 20. pp. 6–10, April, and pp. 31–34, May, 1913. Rev. Électrique, 20. pp. 90–94, July 18, 1913. Abstract.)—An account of various experiments undertaken to improve alkaline accumulators with special regard to porous nickel electrodes of high capacity. Nickel oxide, reduced as in technical practice in carbon tubes at 1800°, yielded small rods of a decidedly porous metal, which remained passive in alkali. Powdered nickel mixed with tar and heated between nickel plates to 1400° did not assume any capacity either. The latter process answered for iron, however; the iron should be heated just to softness, and the tar percentage be such that the iron can take up all the carbon, turning into a grainy pig. Such an iron kathode has a much higher capacity than a nickel electrode, but it is not sufficiently porous to permit diffusion of the electrolyte. Hence another process was tried. Several (up to 10) sheets of fabric (cotton or linen) are carbonised at 1400° between carbon plates; they are then boiled with concentrated hydrochloric acid to extract mineral constituents, and put in a nickel bath of the ammonium-nickel sulphate to receive a very fine coating of nickel; the calculation of the thickness is indicated. Such electrodes can be formed in alkali and coupled with iron kathodes, the cell being packed with nickel-plated carbon texture and charged with caustic alkali. The charge and discharge figures given refer, however, to nickel-plated carbon sheets (as described) mechanically covered with green nickelous oxide and wound with nickel wire. It is stated that a patent has been applied for. H. B.

1564. *Relation between the Magnetic Field and the Passive State of Iron.* III. **H. G. Byers** and **S. C. Langdon.** (Amer. Chem. Soc., Journ. 35. pp. 759–767, June, 1913.)—It has been shown previously [see Abstracts Nos. 1375 (1910) and 121 (1912)] that the establishment of the passive state of iron and nickel anodes requires a higher current density if the apparatus is placed in a magnetic field. It is now found that this retardation depends on the stirring produced by the magnetic field in electrolytes undergoing electrolysis, a similar effect being obtainable by suitable mechanical agitation of the liquid. No satisfactory reason for such an effect is apparent. The experimental results obtained show that passivity is influenced by the following factors: character and condition of the metal, temperature, nature of the electrolyte, current density, duration of current, character and extent of the movements of the electrolyte. No sufficient explanation of passivity has yet been advanced. T. H. P.

1565. *Minimum Voltage of Electrolytic Valves in the Permeable Direction.* **G. Schulze.** (Ann. d. Physik, 41. 3. pp. 593–608, June 24, 1913. Communication from the Physikal-Techn. Reichsanstalt.)—According to the author [see Abstract No. 1140 (1909), etc.] the valve action depends upon the formation of a film of gas in the pores of the oxide skin on the valve metal. A relatively high tension is required to make the "throttled current" flow when the metal is anode; but a certain minimum tension is also required to produce the "flow current" when the metal is kathode. This latter minimum is here investigated. When the anode has been formed by continuous currents and sinusoidal alternating currents are applied, the "flow current" sets in with a minimum voltage at *a* and stops at a point *b* of the oscillograph curve, and the line *ab* may be fairly straight. The curve resembles that of a mercury rectifier and of the electric arc, and the valve does not behave like an ohmic resistance but like a discharge through gas, first passing through the electrolyte in the porous layer. The *a* is mostly sharp, the *b* may be indistinct. The *a* tension depends upon the metal, the thickness of the active layer, and the electrolyte. For equal formation values the *a* is with tantalum 1·5 times greater than with aluminium. In a 0·2-N solution of nitrates the *a* has, with Ta formed at 85 volts a value of about 10 volts when the electrolyte contains alkali-ions, and of about 30 volts for other ions; the value for H-ions is very high, 46·3 volts, and peculiar phenomena are noticed when the respective ions (Ag, Cd, etc.) are easily deposited by the current. It might be thought that the presence of such ions in the electrolyte would render the valve action impossible. The deposition of the ions with the flow current does not follow Faraday's law, and the order of the metals as deposited is not that of ordinary electrolysis. A great number of electrolytes have been tried. H. B.

1566. *Some Factors determining the Kathode Overvoltage.* **J. N. Pring.** (Zeitschr. Elektrochem. 19. pp. 255–262, March 15, 1913. Rev. Électrique, 20. pp. 154–159, Aug. 1, 1913. Abstract.)—Reviewing researches by himself and J. R. Curzon [see Abstract No. 1604 (1912)] and by others with special regard to the influence of surface layers produced by electrolytically depositing certain metals on kathodes of various other metals, the author concludes that the thickness of the surface layers is of importance, so long as a certain max. thickness is not exceeded. This thickness, or depth to which the influence of the overvoltage extends, is very small for Pt, and increases in the order Au, Zn, Cu, Sn, Ni, Pb; the relative thicknesses are 4×10^{-6} mm. for Pt, and $6·6 \times 10^{-3}$ for Pb; they are independent of the kathode metal underneath. The processes of the conversion of the ions into molecules or free gases take place within the metallic layer, the reactions between the ions and metals being limited to a certain depth; hence there is a minimum of polarisation. H. B.